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Levels of Chemical Contaminants in Nonoccupationally Exposed U.S. Residents

Oak Ridge National Laboratory	Operated by Union Carbide Corporation for the Department of Energy Oak Ridge, Tennessee 37830	ORNL/EIS-142/R1
United States Environmental Protection Agency	Health Effects Research Laboratory Research Triangle Park North Carolina 27711	EPA-600/1-80-002

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LEVELS OF CHEMICAL CONTAMINANTS IN NONOCCUPATIONALLY EXPOSED U.S. RESIDENTS

by

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Oak Ridge, Tennessee 37830
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Project Officer

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RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

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This report has been reviewed by the Health Effects Research Laboratory, U.S. Environmental Protection Agency, and approved for publication.

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Bulletin of Environmental Contamination and Toxicology
Drug Metabolism and Disposition
Environmental Health Perspectives
Environmental Research
Food and Cosmetics Toxicology
International Journal of Environmental Studies
Journal of Agricultural and Food Chemistry
Journal of Occupational Medicine
Journal of Toxicology and Environmental Health
Pesticides Monitoring Journal
Toxicology
Toxicology and Applied Pharmacology
Toxicology and Environmental Chemistry Reviews

Abstract Journals

Biological Abstracts
Chemical Abstracts
Excerpta Medica
  Public Health
  Pharmacology and Toxicology
Index Medicus
Nutrition Abstracts and Reviews

Computerized Data Files

DIALOG®
  Food Science and Technology
  Agricola
  Commonwealth Agricultural Bureaux
  Pollution Abstracts
  Chemical Abstracts
  Environline
MEDLINE
ORNL Data Base
  Biological Abstracts/Bioresearch Index
TOXLINE

Other

Document collections of the Information Center Complex, Information Division, Oak Ridge National Laboratory
National Academy of Sciences monographs
Reference document bibliographies
Trace Substances in Environmental Health, Vols. I-IX, proceedings of annual conferences held at the University of Missouri

KEY TO ANALYTICAL TERMINOLOGY

AAS	Atomic absorption spectrometry
ASV	Anodic stripping voltammetry
C	Colorimetry, spectrophotometry
CC	Column chromatography
Ch	Chemical
E	Electrophoresis
ES	Emission spectrometry
F	Fluorometry
FP	Flame photometry
GC	Gas chromatography
GC-EC	Gas chromatography, electron capture detection
GC/MS	Gas chromatography/mass spectrometry
H	Histochemistry
IA	Infrared analysis
IE	Ion exchange
ISE	Ion-specific electrode
M	Microscopy
MS	Mass spectrometry
NA	Not applicable
NAA	Neutron activation analysis
ND	Not detected
NG	Not given
NMR	Nuclear magnetic resonance
R	Radiometry
TLC	Thin-layer chromatography
XRS	X-ray spectroscopy
XRSCh	X-ray spectrochemistry

FOREWORD

The many benefits of our modern, developing, industrial society are accompanied by certain hazards. Careful assessment of the relative risk of existing and new man-made environmental hazards is necessary for the establishment of sound regulatory policy. These regulations serve to enhance the quality of our environment in order to promote the public health and welfare and the productive capacity of our nation's population.

The Health Effects Research Laboratory, Research Triangle Park, conducts a coordinated environmental health research program in toxicology, epidemiology, and clinical studies using volunteer subjects. These studies address problems in air pollution, nonionizing radiation, environmental carcinogenesis, and the toxicology of pesticides as well as other chemical pollutants. The Laboratory participates in the development and revision of air quality criteria documents on pollutants for which national ambient air quality standards exist or are proposed, provides the data for registration of new pesticides or proposed suspension of those already in use, conducts research on hazardous and toxic materials, and is primarily responsible for providing the health basis for nonionizing radiation standards. Direct support to the regulatory function of the Agency is provided in the form of expert testimony and preparation of affidavits as well as expert advice to the Administrator to assure the adequacy of health care and surveillance of persons having suffered imminent and substantial endangerment of their health.

This report documents the chemical contaminants resulting from environmental pollutants and found in the tissue of nonoccupationally exposed U.S. residents as cited in the literature for the past 30 years. Researchers and others interested in this subject should find the tabulated summaries and cited references very useful.

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Director
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ABSTRACT

This report is a compilation of information on chemical contaminants found in nonoccupationally exposed U.S. residents. Listed in tabular form for each of approximately 100 elements or compounds are: the tissue the compound was found in; the range and means or medians of concentrations found; the number of cases; the analytical methods used for detection, identification, and quantitation; the bibliographic reference; information on the source and route of entry of the contaminant into the environment and into man; epidemiological and demographical aspects; and other pertinent comments.

Sources of literature used in the survey cover a 30-year period, with the bulk of the studies coming from the past 10 or 15 years. About 400 references are cited. Some substances that are not necessarily contaminants are included in the report for scientific interest and to establish baselines.

INTRODUCTION

Preparation of this report was directed by the Health and Environmental Studies Program, Information Center Complex, Information Division, Oak Ridge National Laboratory, for the Health Effects Research Laboratory, U.S. Environmental Protection Agency, as partial fulfillment of Interagency Agreement DOE No. 40-673-78 and EPA No. 78-D-X0205 between the Department of Energy and the U.S. Environmental Protection Agency. The scope of this report is designed to meet the obligation of the U.S. Environmental Protection Agency as specified in Section 403c(1) of the Clean Air Act as amended August 7, 1977. This section provides for the following:

> (c)(1) Not later than twelve months after the date of enactment of this Act the Administrator of the Environmental Protection Agency shall publish throughout the United States a list of all known chemical contaminants resulting from environmental pollution which have been found in human tissue including blood, urine, breast milk, and all other human tissue. Such list shall be prepared for the United States and shall indicate the approximate number of cases, the range of levels found, and the mean levels found.

Work under this agreement will continue until a comprehensive final report is prepared which will meet the additional requirements of Section 403c(2):

> (2) Not later than eighteen months after the date of enactment of this Act the Administrator shall publish in the same manner an explanation of what is known about the manner in which the chemicals described in paragraph (1) entered the environment and thereafter human tissue.

A preliminary report, of which this document is the final version, was published in August 1978 to satisfy the requirements of Section 403 c(1). A companion report, *Chemical Contaminants in Nonoccupationally Exposed U.S. Residents*, ORNL/EIS-153, is being published to satisfy the requirements of Section 403c(2).

Representative data on the human tissue levels of all chemicals considered pertinent to the intended scope of this report are included in the subsequent tables. Demographic data or any other information considered important for understanding the significance of the reported chemical levels are also included. Chemical coverage reflects tissue levels reported over the last 30 years, although imposed time constraints did not allow documentation of every report. A list of the information resources surveyed is provided at the end of this section and a reference list following the tables contains the sources used in the report.

Most available data result from specific surveys that determine the tissue levels of chemicals perceived to be potential public health hazards or from chemicals involved in incidents of gross accidental poisonings.

Basic interests in the roles of trace elements and recognition of the need to determine baseline levels of chemicals introduced into the environment are additional factors which have motivated surveys by individual investigators. Thus, most data on chemicals in human tissues record: levels of pesticides such as DDT and metabolites; levels of trace metals such as lead, cadmium, and mercury; or levels of nutritionally essential elements such as zinc, copper, manganese, and fluoride.

The considerable amount of data available on some essential elements, such as iron and calcium, is not presented in this report because their presence in the environment is generally not considered hazardous. Data on several uncommon chemicals, such as indium and ytterbium, are included basically as items of interest and to further document their presence in healthy individuals. Baseline data were presented where available to provide perspective as to chemical levels which might be expected under conditions where exposure could be considered normal or not directly related to a pollutant source.

Approximately 400 cited surveys or investigations, most reported within the past decade, are listed in the following tables. Ninety-five different chemical contaminants, primarily trace metals and organochlorine pesticides, were reported. It is estimated that over 75% of the data published during the past 30 years on chemical contaminants derived from environmental pollution and found in human tissue in the United States are represented in this report. The post-World War II period covered in this survey represents that period when the proliferation of new chemical substances emitted into the environment was increasing at an accelerated pace.

Table 1. Aldrin

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	NG	NG	NG	0.26 mg/kg		Hunter, Robinson, and Jager, 1967
Blood	53 pairs	GC	0.2-0.7 ppb	0.41 ppb	Maternal blood, Louisiana housewives	Selby, Newell, Hauser, and Junker, 1969
	62	GC, TLC	0.1-65.3 ppb	0.67 ppb	General population	Selby, Newell, Waggenspack, Hauser, and Junker, 1969
Placenta	53 pairs	GC	3.0-7.2 ppb	4.77 ppb	Childbirth, Louisiana housewives	Selby, Newell, Hauser, and Junker, 1969

Table 2. Aluminum

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adrenal	13	ES	62-450 µg/g ash	180 µg/g ash (median)		Tipton and Cook, 1963
Aorta	100	ES	0.94-51.0 micromoles/g ash	NG		Perry, 1968
	150	ES	0.76-5.2 micromoles/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	104	ES	11-140 µg/g ash	29 µg/g ash (median)		Tipton and Cook, 1963
Bladder	2	ES	NG	6.0 ppm wet wt	Organs from sudden accident victims, normal	Koch et al., 1956
	110	ES	18-150 µg/g ash	47 µg/g ash (median)		Tipton and Cook, 1963
Blood	48	ES	NG	0.0207 ± 0.0008 mg/100 ml	Normal individuals, Los Angeles area	Butt et al., 1964
	266	ES	0.040-0.045 ± 0.03 mg/100 ml	0.043 mg/100 ml	Patients, blood donors, and normal individuals, Los Angeles area, serum	Butt et al., 1964
	NG	ES	NG	0.013 mg/100 g wet wt	Race and country information, diet	Kehoe, Cholak, and Story, 1940
Bone	NG	ES	NG	0.5 mg/100 g wet wt	Race and country information, diet, long bone	Kehoe, Cholak, and Story, 1940
	NG	ES	NG	0.24 mg/100 g wet wt	Race and country information, diet, rib bone	Kehoe, Cholak, and Story, 1940
Brain	NG	ES	NG	0.004 mg/100 g wet wt	Race and country information, diet	Kehoe, Cholak, and Story, 1940
	3	ES	NG	8.0 ppm wet wt	Organs from sudden accident victims, normal	Koch et al., 1956
	100	ES	0.38-10.0 micromoles/g ash	NG		Perry, 1968
	150	ES	0.22-1.4 micromoles/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	127	ES	6-38 µg/g ash	15 µg/g ash (median)		Tipton and Cook, 1963
Diaphragm	91	ES	13-94 µg/g ash	26 µg/g ash (median)		Tipton and Cook, 1963
Esophagus	1	ES	NG	20.0 ppm wet wt	Organs from sudden accident victims, normal	Koch et al., 1956
	66	ES	25-180 µg/g ash	61 µg/g ash (median)		Tipton and Cook, 1963

Table 2. Aluminum (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Feces	2	ES	NG	17 ± 3 and 15 ± 2 mg/day	Volunteers, balance studies	Tipton, Stewart, and Dickson, 1969
Hair	99	NAA	2.0-9.0 ppm	4.4 ppm	Children and adults	Bate and Dyer, 1965
	18	ES	5.5×10^{-12} to 2.1×10^{-9}% dry wt	NG	White males, 15-70 years old	Goldblum, Derby, and Lerner, 1953
	2	AAS, MS	3.7 and 4.6 µg/g dry wt	NG		Yurachek, Clemens, and Harrison, 1969
Heart	NG	ES	NG	0.056 mg/100 g wet wt	Race and country information, diet	Kehoe, Cholak, and Story, 1940
	100	ES	0.87-20.0 micromoles/g ash	NG		Perry, 1968
	150	ES	0.37-2.0 micromoles/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	140	ES	10-70 µg/g ash	20 µg/g ash (median)		Tipton and Cook, 1963
Intestine	NG	ES	NG	0.087 mg/100 g wet wt	Race and country information, diet	Kehoe, Cholak, and Story, 1940
	6	ES	0.0-20.0 ppm wet wt	8.0 ppm wet wt	Sudden accident victims	Koch et al., 1956
Cecum	31	ES	24-780 µg/g ash	130 µg/g ash (median)		Tipton and Cook, 1963
Ileum	82	ES	25-200 µg/g ash	86 µg/g ash (median)		Tipton and Cook, 1963
Duodenum	NG	NG	18-260 µg/g ash	43 µg/g ash (median)		Tipton and Cook, 1963
Jejunum	101	ES	18-150 µg/g ash	37 µg/g ash (median)		Tipton and Cook, 1963
Sigmoid colon	107	ES	23-340 µg/g ash	107 µg/g ash (median)		Tipton and Cook, 1963
Rectum	42	ES	18-200 µg/g ash	72 µg/g ash (median)		Tipton and Cook, 1963
Kidney	NG	ES	NG	0.042 mg/100 g wet wt	Race and country information, diet	Kehoe, Cholak, and Story, 1940
	100	ES	1.1-31.0 micromoles/g ash	NG		Perry, 1968
	150	ES	0.51-3.0 micromoles/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	NG	ES	0-15+ mg/100 g dry wt	NG		Tietz, Hirsch, and Neyman, 1957
	141	ES	14-82 µg/g ash	25 µg/g ash (median)		Tipton and Cook, 1963

Table 2. Aluminum (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Larynx	50	ES	6-51 µg/g ash	14 µg/g ash (median)		Tipton and Cook, 1963
Liver	NG	ES	NG	0.16 mg/100 g wet wt	Race and country information, diet	Kehoe, Cholak, and Story, 1940
	3	ES	0.0-12.0 ppm wet wt	6.0 ppm wet wt	Organs from sudden accident victims, normal	Koch et al., 1956
	100	ES	1.3-18.0 micromoles/g ash	NG		Perry, 1968
	150	ES	0.62-4.4 micromoles/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	10	ES	NG	80.0 ± 85.4 µg/g ash	Five white and five black accident victims, long-term St. Louis residents	Perry et al., 1973
	NG	ES	0-15+ mg/100 g dry tissue	NG		Tietz, Hirsch, and Heyman, 1957
	140	ES	17-120 µg/g ash	47 µg/g ash (median)		Tipton and Cook, 1963
	12	ES, Ch	NG	0.69 ± 0.05 to 0.85 ± 0.3 ppm	Autopsies, low value for cirrhotic patients (alcoholics) and high value for noncirrhotic patients	Vallee et al., 1957
Lung	NG	ES	NG	5.94 mg/100 g wet wt	Race and country information, diet	Kehoe, Cholak, and Story, 1940
	3	ES	6.0-180 ppm wet wt	50.0 ppm wet wt	Organs from sudden accident victims, normal	Koch et al., 1956
	100	ES	49-330 micromoles/g ash	NG		Perry, 1968
	150	ES	29-190 micromoles/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	168	NG	NG	Min — 1700 µg, max — 80,000 µg, and retained per year — 667 µg	Autopsy samples from 58 cities and 29 nonurban areas	Schroeder, 1970b
	NG	ES	0-20+ mg/100 g dry wt	NG		Tietz, Hirsch, and Heyman, 1957
	141	ES	170->4000 µg/g ash	2500 µg/g ash	Autopsies, nine U.S. cities	Tipton and Shafer, 1964
	141	ES	780->4000 µg/g ash	2000 µg/g ash (median)		Tipton and Cook, 1963

Table 2. Aluminum (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Muscle	NG	ES	NG	0.015 mg/100 g wet wt	Race and country information, diet	Kehoe, Cholak, and Story, 1940
	7	ES	0.0-12.0 ppm wet wt	6.0 ppm wet wt	Organs from sudden accident victims, normal	Koch et al., 1956
	136	ES	6-77 µg/g ash	16 µg/g ash (median)		Tipton and Cook, 1963
Nails	18	ES	4.5×10^{-11} to 5.3×10^{-8}% dry wt	NG	White males, 15-70 years old	Goldblum, Derby, and Lerner, 1953
Omentum	75	ES	68-1100 µg/g ash	180 µg/g ash (median)		Tipton and Cook, 1963
Ovary	16	ES	12-150 µg/g ash	36 µg/g ash (median)		Tipton and Cook, 1963
Pancreas	138	ES	12-160 µg/g ash	27 µg/g ash (median)		Tipton and Cook, 1963
Prostate	50	ES	12-220 µg/g ash	46 µg/g ash (median)		Tipton and Cook, 1963
Skin	18	ES	5.3×10^{-11} to 4.5×10^{-9}% dry wt	NG	White males, 15-70 years old	Goldblum, Derby, and Lerner, 1953
	22	ES	72-1200 µg/g ash	260 µg/g ash (median)		Tipton and Cook, 1963
Spleen	NG	ES	NG	0.13 mg/100 g wet wt	Race and country information, diet	Kehoe, Cholak, and Story, 1940
	3	ES	0.0-8.0 ppm wet wt	7.0 ppm wet wt	Organs from sudden accident victims, normal	Koch et al., 1956
	100	ES	0.95-18.0 micromoles/g ash	NG		Perry, 1968
	150	ES	0.36-4.4 micromoles/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	143	ES	10-120 µg/g ash	25 µg/g ash (median)		Tipton and Cook, 1963
Stomach	NG	ES	NG	0.073 mg/100 g wet wt	Race and country information, diet	Kehoe, Cholak, and Story, 1940
	3	ES	7.0-40.0 ppm wet wt	18.0 ppm wet wt	Organs from sudden accident victims, normal	Koch et al., 1956
	130	ES	16-110 µg/g ash	35 µg/g ash (median)		Tipton and Cook, 1963
Teeth	208	MS			Subjects less than 20 years old, enamel:	Curzon and Losee, 1977
				19.13 ± 3.48 ppm	high caries area, New England	
				8.34 ± 1.31 ppm	low caries area, South Carolina	

Table 2. Aluminum (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	56	MS	1.5–54.0 μg/g	14.0 ± 1.51 μg/g	Subjects less than 20 years old, wide geographic area	Losee, Cutress, and Brown, 1973
Testis	72	ES	16–80 μg/g ash	30 μg/g ash (median)		Tipton and Cook, 1963
Thyroid	21	ES	35–240 μg/g ash	85 μg/g ash (median)		Tipton and Cook, 1963
Total body content	168	NC	NC	61 mg	Autopsy samples from 58 cities and 29 nonurban areas	Schroeder, 1970*b*
Trachea	60	ES	12–890 μg/g ash	57 μg/g ash (median)		Tipton and Cook, 1963
Urine	NC	ES	NC	0.078 mg/liter	Race and country information, diet	Kehoe, Cholak, and Story, 1940
	2	ES	NC	0.87 ± 0.07 and 0.72 ± 0.04 mg/day	Volunteers, balance studies	Tipton, Stewart, and Dickson, 1969
Uterus	32		12–90 μg/g ash	36 μg/g ash (median)		Tipton and Cook, 1963
Vena cava	1	ES	NC	8.0 ppm wet wt	Organs from sudden accident victims, normal	Koch et al., 1956

Table 3. Antimony

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00-0.31 ppm	NG	Mean age 35.3 years, serum	Gofman et al., 1964
	NG	NG	NG	0.016 µg/ml	Normal level	Rentoul and Smith, 1973
Brain	NG	NG	NG	0.11 µg/g dry wt	Normal level	Rentoul and Smith, 1973
Hair	33	NAA	0.5-4.0 ppm	1.5 ppm	Adults and children, Oak Ridge, Tennessee	Bate and Dyer, 1965
	10	NAA	NG	0.061 ± 0.013 ppm	Homogenized hair	Obrusnik et al., 1972
	NG	NG	NG	0.69 µg/g dry wt	Normal level	Rentoul and Smith, 1973
Heart	NG	NG	NG	0.09 µg/g dry wt	Normal level	Rentoul and Smith, 1973
Kidney	NG	NG	NG	0.17 µg/g dry wt	Normal level	Rentoul and Smith, 1973
Liver	NG	NG	NG	0.19 µg/g dry wt	Normal level	Rentoul and Smith, 1973
Lung	24	NAA	<0.010-0.87 µg/g wet wt	0.116 µg/g wet wt	Some cases with lung cancer, some without	Kennedy, 1966
Teeth	56	MS	0.02-0.34 µg/g dry wt	0.13 µg/g dry wt	Less than 20-year-old teeth, enamel	Losee, Cutress, and Brown, 1973

Table 4. Arsenic

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	16	C	0.00-0.15 mg/100 g dry wt	0.0529 mg/100 g dry wt	Normal children	Cannon, 1936
	55	C	<1->1 mg/100 g dry wt	0.26 mg/100 g dry wt	Normal adults	
	107	C	Trace to 4.86 mg/100 g dry wt	NG	Patients with suggestion of chronic arsenic poisoning	
	NG	XRS	0.00-0.05 ppm	NG		Gofman et al., 1964
	NG	NG	NG	0.03 µg/ml	Normal level	Rentoul and Smith, 1973
	53	NG	10-360 ppb	32-251 ppb	Six Oregon cities, correlation of blood arsenic level with arsenic levels in drinking water	Whanger, Weswig, and Stoner, 1977
Brain	NG	NG	NG	0.016 µg/g dry wt	Normal level	Rentoul and Smith, 1973
Hair	160	AAS	NG	0.09 µg/g (mean), 0.08 (median)	Children in nonsmelter towns	Baker et al., 1977
	872	AAS		2.60 (mean), 0.38 (median)	Children in copper smelter towns	Baker et al., 1977
	43	Ch	0.25-0.88 µg/g	0.51 µg/g		Camp and Gant, 1949
	168	C	NG	0.4 ± 0.26 to 10.6 ± 7.0 ppm	Mean level range represents five cities, fourth-grade boys	Hammer, Finklea, Hendricks, Shy, and Horton, 1971
	NG	AAS	20-100 ppm	50 ppm	Children living near smelter	Milham and Strong, 1974
	NG	AAS	0-4 ppm	3 ppm	Children 8 miles from smelter	
	NG	NG	NG	0.65 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	2	AAS, ES	0.06 and 0.31 µg/g dry wt	NA		Yurachek, Clemens, and Harrison, 1969
Heart	NG	NG	NG	0.027 µg/g dry wt	Normal level	Rentoul and Smith, 1973
Kidney	NG	NG	NG	0.050 µg/g dry wt	Normal level	Rentoul and Smith, 1973
Liver	NG	NG	NG	0.057 µg/g dry wt	Normal level	Rentoul and Smith, 1973
Placenta	58	NG	NG	0.001 ± 0.000 µg/g wet wt	Southern and southeastern city hospitals	Karp and Robertson, 1977
Skin	NG	NG	High value - 5.22 mg/100 g dry wt	NG	Samples from patients exhibiting symptoms suggestive of chronic arsenic poisoning	Cannon, 1936

Table 4. Arsenic (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	87	NAA	0.01-3.50 µg/g dry wt 0.05-2.30 µg/g dry wt	0.17 µg/g dry wt 0.10 µg/g dry wt	Arsenic history No arsenic history	Domonkos, 1959
Urine	193	AAS	NG	5.8 µg/liter (geometric mean), 7.3 (median)	Children in nonsmelter towns	Baker et al., 1977
	712	AAS		18.7 (geometric mean), 19.8 (median)	Children in copper smelter towns	Baker et al., 1977
	107	C	Trace to 4.86 mg/100 g dry wt	NG	Patients exhibiting symptoms suggestive of chronic arsenic poisoning	Cannon, 1936
	16	C	NG	0.130 mg/liter	Normal adults	Cannon, 1936
	NG	NAA	NG	0.023 mg/liter	Children	Gilla et al., 1974
	28	XRS	5-114 µg/liter 8-75.5 µg/24 hr	20 ± 13.6 and 29.1 ± 25.3 µg/liter, 20.9 ± 11.3 and 39.1 ± 23.4 µg/24 hr	Measurements from Denver and Seattle	Mathies, 1974
	NG	AAS	0.01-0.3 ppm 0.01-0.05 ppm	0.097 ppm 0.034 ppm	Children living near smelter Children 8 miles from smelter	Milham and Strong, 1974
	NG	NG	NG	0.084 µg/ml	Normal level	Rentoul and Smith, 1973

Table 5. Asbestos, ferruginous bodies

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Lung	282	M	0.0-<210 particles per lung	14.20 particles per lung	Duluth, 1953-1955	Auerbach et al., 1977
				12.89 particles per lung	Duluth, 1960-1961	
				7.42 particles per lung	Duluth, 1966-1967	
	96			10.05 particles per lung	Duluth, 1972-1973	
				13.55 particles per lung	New York City, 1966-1968	
	41 of 100	M	NG	NG		Cauna, Tollen, and Gross, 1965
	28	M	1-20 particles per 5 g	NG	Samples from ages 10-70	Gordon, Rosen, and Savino, 1976
	23	NG	NG	2.8 mg/g dry wt	Charleston, South Carolina, autopsies	Gross et al., 1974
				9.5 mg/g dry wt		
				6.5×10^3 fibers per gram	Pittsburgh, Pennsylvania, autopsies	
				45.2×10^3 fibers per gram		
	28 of 28	M	9->201 fibers per sample of tissue ($1/10^4$ of total lung tissue)	NG	New York City autopsies	Langer et al., 1970; Selikoff, Nicholson, and Langer, 1972
	1449 of 3000	M	0.0-57.0% positive	NG	New York City autopsies	Langer et al., 1970
	28 of 28	M	3-340 fibers per sample of tissue	NG	New York City random autopsies	Langer, Selikoff, and Sastre, 1971
	24 of 28	M	NG	NG	New York City autopsies, general population	Langer, Selikoff, and Sastre, 1971
	86	M	0-251+ ferruginous bodies per 5 g tissue	NG	No difference due to sex or location	Rosen, Melamed, and Savino, 1972
	179 of 355	M	NG	NG	New York City autopsies	Selikoff and Hammond, 1968
		M			Autopsies in Florida:	Thomson and Graves, 1966
	304		NG	31.6% positive	males	
	196		NG	20.4% positive	females	
	100	M	NG	98.2% positive	Males	Utidjian, Gross, and deTreville, 1968
				95.5% positive	Females	

Table 6. Barium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adrenal	13	ES	1.2–12 μg/g ash	6.0 μg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Aorta	100	ES	0.036–0.50 micromole/g ash	NG		Perry, 1968
	150	ES	0.018–0.12 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	103 of 105	ES	2.5–17 μg/g ash	7.0 μg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Bladder	106 of 110	ES	0.6–8.0 μg/g ash	3.4 μg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Blood	48	ES	NG	0.0069 ± 0.0004 mg/100 ml	Normal individuals, Los Angeles area, whole blood	Butt et al., 1964
	266	ES	0.005–0.470 mg/100 ml	0.171 mg/100 ml	Patients, blood donors, and normal individuals, Los Angeles, serum	Butt et al., 1964
	39	XRS	0.00–0.44 ppm	NG	Males, mean age 35.3 years, serum	Gofman et al., 1964
	NG	NG	NG	0.07 μg/ml		Rentoul and Smith, 1973
Bone	35	NAA	1.9–17.3 ppm	7.0–8.5 ppm	Four groups: 0–3 months to 33–74 years, increased slightly with age	Sowden and Stitch, 1957
Brain	100	ES	0.015–0.19 micromole/g ash	NG		Perry, 1968
	150	ES	<0.001–0.013 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	NG	NG	NG	0.01 μg/g dry wt		Rentoul and Smith, 1973
	66 of 129	ES	<0.2–1.8 μg/g ash	0.2 μg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Diaphragm	76 of 91	ES	<0.2–4.2 μg/g ash	1.8 μg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Esophagus	66	ES	0.6–1.2 μg/g ash	3.0 μg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Feces	2	ES	NG	0.69 ± 0.08 and 0.88 ± 0.18 mg/day	Volunteers, balance study	Tipton, Stewart, and Dickson, 1969
Hair		ES				
	267		0.054–9.29 μg/g	0.762 μg/g	Three New York City areas: children	Creason et al., 1975
	197		0.121–29.0 μg/g	1.41 μg/g	adults	
	2	AAS, MS	NG	0.60 and 0.46 μg/g dry wt		Yurachek, Clemena, and Harrison, 1969

Table 6. Barium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Heart	100	ES	0.017-0.24 micromole/g ash	NG		Perry, 1968
	150	NG	<0.001-0.020 micromole/ ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	NG	NG	NG	0.08 µg/g dry wt		Rentoul and Smith, 1973
	93 of 140	ES	<0.2-3.1 µg/g ash	0.7 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Intestine						
Duodenum	65 of 67	ES	1.2-8.4 µg/g ash	3.7 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Jejunum	99 of 101	ES	0.9-8.4 µg/g ash	4.0 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Ileum	34	ES	3.8-28 µg/g ash	9.2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Cecum	31	ES	5.4-31 µg/g ash	18 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Sigmoid colon	108	ES	1.7-38 µg/g ash	6.1 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Rectum	41 of 42	ES	2.0-37 µg/g ash	7.2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Kidney	100	ES	0.018-0.170 micromole/g ash	NG		Perry, 1968
	150	ES	<0.001-0.029 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	NG	NG	NG	0.06 µg/g dry wt		Rentoul and Smith, 1973
	121 of 142	ES	<0.2-4.0 µg/g ash	1.3 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Larynx	50	ES	2.4-13 µg/g ash	5.3 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Liver	100	ES	<0.001-0.12 micromole/g ash	NG		Perry, 1968
	150	ES	<0.001-0.015 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	10	ES	NG	0.67 ± 0.40 µg/g ash	Five white and five black accident victims, long-term St. Louis residents	Perry et al., 1973
	NG	NG	NG	0.007 µg/g dry wt		Rentoul and Smith, 1973
	68 of 146	ES	<0.2-2.1 µg/g ash	<0.2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Lung	100	ES	0.068-0.340 micromole/g ash	NG		Perry, 1968

Table 6. Barium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	150	ES	0.029-0.290 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	168	NG	NG	Min – <20 µg, max – 1000 µg, and retained per year – 47 µg	Autopsy samples from 58 cities and 29 nonurban areas	Schroeder, 1970*b*
	139 of 140	ES	4.1-40 µg/g ash	14 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
	139 of 140	ES	<0.2-100 µg/g ash	14 µg/g ash (median)	Autopsies, nine U.S. cities	Tipton and Shafer, 1964
Muscle	77 of 136	ES	<0.2-2.7 µg/g ash	0.3 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Omentum	74 of 75	ES	2.9-27 µg/g ash	7.0 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Ovary	14 of 16	ES	<0.2-8.7 µg/g ash	2.9 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Pancreas	108 of 139	ES	<0.2-4.6 µg/g ash	1.6 µg/g ash	U.S. tissues	Tipton and Cook, 1963
Placenta	58	NG	NG	0.053 ± 0.01 µg/g wet wt		Karp and Robertson, 1977
Prostate	44 of 50	ES	<0.2-9.9 µg/g ash	2.1 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Skin	22	ES	4.0-35 µg/g ash	8.2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Spleen	100	ES	0.009-0.18 micromole/g ash	NG		Perry, 1968
	150	ES	<0.001-0.024 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	89 of 143	ES	<0.2-3.3 µg/g ash	0.6 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Stomach	126 of 130	ES	0.9-8.8 µg/g ash	3.2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Teeth						
	208	MS	NG	6.8 ± 2.26 ppm 2.1 ± 0.57 ppm	Subjects less than 20 years old, enamel: high caries area, New England low caries area, South Carolina	Curzon and Losee, 1977
	56	MS	0.8-17.0 µg/g	5.6 µg/g	Subjects less than 20 years old, wide geographic area, enamel	Losee, Cutress, and Brown, 1973
Testis	54 of 72	ES	<0.2-3.6 µg/g ash	1.1 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963

Table 6. Barium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Thyroid	20 of 21	ES	1.8–33 µg/g ash	5.8 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Total body content	168	NG	NG	22.0 mg	Autopsy samples from 58 cities and 29 nonurban areas	Schroeder, 1970*b*
Trachea	60	ES	1.0–13 µg/g ash	5.0 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Urine	2	ES	NG	0.037 ± 0.012 and 0.017 ± 0.003 mg/day	Volunteers, balance study	Tipton, Stewart, and Dickson, 1969
Uterus	27 of 32	ES	<0.2–55 µg/g ash	2.0 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963

Table 7. α-Benzene hexachloride

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	25	GC	NG	<0.03 ppm	Samples from Los Angeles	Hayes, Dale, and Burse, 1965
	1412	GC-EC	0.0-0.14 ppm	0.01 ppm (only 2.05% positive)	Reflects the levels in the U.S. population of the conterminous 48 states, 1970, lipid basis	Kutz et al., 1974*b*
Blood	1000	GC-EC	0.0-18.0 ppb	<0.07 ppb	General population in Idaho	Watson, Benson, and Gabica, 1970
Milk	1436	GC-EC	<1.0-104.4 ppb	56.3 ppb	Not detectable in 1426 of 1436 samples, fat basis	Savage, 1976

Table 8. β-Benzene hexachloride

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	NG	GC/MS	NG	0.95 ppm		Biros and Walker, 1970
	221	GC-EC	NG	1.23 ± 0.95 ppm	Texas agricultural areas, tissues from surgery	Burns, 1974
	25	GC-EC	0.1-0.5 ppm	0.2 ppm		Davies et al., 1971
	25	GC	0.03-2.43 ppm	0.6 ± 0.1 ppm		Hayes, Dale, and Burse, 1965
	1412	GC-EC	0.0-26.9 ppm	0.60 ppm	Reflects the levels in the U.S. population of the conterminous 48 states, 1970, lipid basis	Kutz et al., 1974b
	6933	GC-EC	0.0-26.9 ppm, trace to 26.93 ppm	0.37-0.21 ppm, FY 1970-FY 1974 (geometric mean)	U.S. sites reflective of general population in conterminous 48 states, FY 1970-FY 1974, lipid basis	Kutz, Strassman, and Yobs, 1976, 1977; Kutz, Yobs, and Strassman, 1977
	1734	GC-EC	5.76, 3.06, max 1973, 1974	0.25, 0.21 ppm (geometric mean), 1973, 1974	Whites and blacks respectively. Reflective of U.S. population of conterminous 48 states, lipid basis	Kutz, Yobs, and Strassman, 1977
	240	GC-EC	Trace to 2.74 ppm	0.31, 0.25 ppm (geometric mean), 1973, 1974		
	332	GC-EC	0.37-2.28 ppm	NG	Autopsies in Florida	Radomski et al., 1968
	202	GC-EC	0.0-2.5 ppb	0.3 ppb	Whites in Idaho	Wyllie, Gabica, and Benzon, 1972
Blood	20	GC			General population, 10 males and 10 females:	Dale, Curley, and Hayes, 1967
			0.0024-0.0184 ppm	0.0065 ± 0.0015 ppm	plasma, males	
			0.0008-0.0057 ppm	0.0025 ± 0.0005 ppm	plasma, females	
			0.0012-0.0133 ppm	0.0047 ± 0.0012 ppm	RBC, males	
			0.0012-0.0054 ppm	0.0026 ± 0.0003 ppm	RBC, females	
			0.0013-0.0208 ppm	0.0060 ± 0.0018 ppm	whole blood, males	
			0.0003-0.0035 ppm	0.0022 ± 0.0004 ppm	whole blood, females	
	10	GC-EC	NG	0.042 ppm	Females, no occupational exposure:	Dale et al., 1966
			0.0015-0.002 ppm	0.0034 ppm	Plasma	
			0.0019-0.0042 ppm	0.0031 ppm	Whole blood	
			0.0005-0.0022 ppm	0.0010 ppm	RBC	
			0.0004-0.0094 ppm	0.0036 ppm	Serum	
	350 pairs	GC	1.0-3.0 ppb	NG	Mother-infant pairs, blood pairs	D'Ercole et al., 1976

Table 8. β-Benzene hexachloride

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	1619	GC	0.0-8.0 ppb	0.46 ppb	General population in Hawaii	Klemmer, Rashad, and Mi, 1973
	28	GC-EC	NG	1.40 ± 0.46 ppb	Four males and four females, 27-49 years old, 20 autopsies	Radomski et al., 1971
	8+	GC	0.7-2.0 ppb 1.0-3.2 ppb	1.4 ± 0.46 ppb NG	Whole blood Plasma	Radomski et al., 1971
	3568	NG	NG	0.7 ± 1.5 ppb	General population of Hawaii	Rashed et al., 1976
	1000	GC-EC	0.0-15.0 ppb	<0.07 ppb	Blood serum, general population in Idaho	Watson, Benson, and Gabica, 1970
	202	GC-EC	0.0-15.0 ppb	0.3 ppb	Blood serum, whites in Idaho	Wyllie, Gabica, and Benson, 1972
Brain	332	GC-EC	Trace to 0.0	NG	Autopsies in Florida	Radomski et al., 1968
Liver	332	GC-EC	0.06 ± 0.10 to 0.12 ± 0.18 ppm	NG	Autopsies in Florida	Radomski et al., 1968
Milk	40	GC	Trace to 38.0 ppb	5.6 ppb, fat basis	Females	Savage et al., 1973
	1436	GC-EC	<1.0-9216.6 ppb	193.1 ppb, fat basis	National study	Savage, 1976
	57	GC-EC, GC/MS	Trace to 0.01 ppm	0.005 ppm	Selected areas of Missouri and Arkansas, 1973, 1974, 27% blacks, whole-milk basis	Strassman and Kutz, 1977; Kutz, Strassman, and Yobs, 1976

Table 9. γ-Benzene hexachloride (lindane)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	282	GC	≤0.1-12.3 ppm	0.56 ppm		Hoffman, Harrison, and Schaefer, 1964
	994	GC	0.0-12.3 ppm	0.48 ppm	Autopsies	Hoffman et al., 1967
	1412	GC-EC	0.0-0.18 ppm	0.01 ppm	Reflects the levels in the U.S. population of the conterminous 48 states, 1970, lipid basis	Kutz et al., 1974*b*
	1734 240	GC-EC GC-EC	Trace to 0.10 ppm Trace to 0.05 ppm	NG (only about 1% had detectable levels)	Whites and blacks respectively. Representative of U.S. population of conterminous 48 states, lipid basis	Kutz Yobs, and Strassman, 1977
Blood	86	GC-EC	0.0-23.0 ppb	4.71 ppb 2.79 ppb 3.60 ppb	Blood plasma: males females combined	Burns and Miller, 1975
	20	GC	<0.0005-0.0132 ppm <0.0003-0.0019 ppm <0.0005-0.0023 ppm 0.0007-0.0019 ppm <0.0005-0.0080 ppm 0.0007-0.0018 ppm	0.0057 ± 0.0019 ppm 0.0008 ± 0.0002 ppm 0.0008 ± 0.0002 ppm 0.0012 ± 0.0001 ppm 0.0015 ± 0.0008 ppm 0.0014 ± 0.0001 ppm	General population, 10 males and 10 females: plasma, males plasma, females RBC, males RBC, females whole blood, males whole blood, females	Dale, Curley, and Hayes, 1967
	28	GC	0.0-10.2 ppb	1.6 ppb	Blood serum, Texas females	Dyment, Hebertson, Gomes, Wiseman, and Hornabrook, 1971
	80	NG	NG	0.1 ppb 11.5 ppb	Nonexposed controls Exposed occupationally	Milby and Samuels, 1971
	553 pairs	GC-EC	0.1-6.0 ppb	0.39 ppb	General population in Louisiana, mother-infant pairs	Selby, Newell, Hauser, and Junker, 1969
	53 pairs	GC-EC	0.1-7.4 ppb	0.48 ppb	General population in Louisiana, mother-infant pairs, total benzene hexachloride	Selby, Newell, Hauser, and Junker, 1969
	1000	GC-EC	0.0-24.0 ppb	<0.07 ppb	General population in Indiana	Watson, Benson, and Gabica, 1970
Feces	32	GC	Trace to 0.12 µg/day per person	NG		Price, Young, and Dickinson, 1972

Table 9. γ-Benzene hexachloride (lindane) (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Milk	28	GC	0.0-37.0 ppb	7.2 ppb	Blood serum, Texas females	Dyment, Herbertson, Gomes, Wiseman, and Hornabrook, 1971
	53	GC	0.03-0.20 mg/kg	0.115 mg/kg, fat basis	Milk fat, nursing mothers in Pennsylvania	Kroger, 1972
	23	GC-EC	71.0-247.2 ppb	571.0 ppb, fat basis	γ-Benzene hexachloride, not detectable in 1413 of 1436 samples	Savage, 1976
	663	GC-EC	<1.0-1444.4 ppb	77.7 ppb, fat basis	Total benzene hexachloride, not detectable in 773 of 1436 samples	Savage, 1976
Placenta	53 pairs	GC-EC	0.1-6.0 ppb	1.19 ppb	General population in Louisiana, mother-infant pairs	Selby, Newell, Hauser, and Junker, 1969
Urine	32	EC	Trace to 0.06 µg/day per person	NG		Price, Young, and Dickinson, 1972

Table 10. A-Benzene hexachloride

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	1412	GC-EC	0.0-1.11 ppm	0.01 ppm	32 cities	Kutz et al., 1974*b*

Table 11. Beryllium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	1	F	<0.0004 ppm	NA	Cadaver	Forbes, Cooper, and Mitchell, 1954
Blood	NG	NG	NG	0.0001 µg/ml	Normal blood level	Rentoul and Smith, 1973
Bone	1	F	<0.0004 ppm	NA	Cadaver, skeletal bone	Forbes, Cooper, and Mitchell, 1954
Brain	NG	NG	NG	0.002 µg/g dry wt	Normal level	Rentoul and Smith, 1973
Gastrointestinal tract	NG	F	<0.0004 ppm	NA	Cadaver	Forbes, Cooper, and Mitchell, 1954
Heart	NG	NG	NG	0.002 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	1	F	<0.0004 ppm	NA	Cadaver	Forbes, Cooper, and Mitchell, 1954
Kidney	NG	NG	NG	0.002 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	NG	ES	0-0.5 mg/100 g tissue	NG	Cancer patients and autopsy specimens	Tietz, Hirsch, and Neyman, 1957
Liver	NG	ES	0-1.0 mg/100 g tissues	NG	Cancer patients and autopsy specimens	Tietz, Hirsch, and Neyman, 1957
	NG	NG	NG	0.0009 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	1	F	0.001 ppm	NA	Cadaver	Forbes, Cooper, and Mitchell, 1954
	2	NG	0-0.012 µg/100 g	NG	One white male and one black male	Forbes, Mitchell, and Cooper, 1956
Lung	2	NG	0-0.023 µg/100 g	NG	One white male and one black male	Forbes, Mitchell, and Cooper, 1956
	1	F	<0.0004 ppm	NA	Cadaver	Forbes, Cooper, and Mitchell, 1954
	3	MS	0.1-1.1 µg/100 g tissues	NG		Robinson et al., 1968
	NG	ES	0-1.0 mg/100 g dry wt	NG	Cancer patients and autopsy specimens	Tietz, Hirsch, and Neyman, 1957
Placenta	58	NG	NG	0.013 ± 0.007 µg/g wet wt	Southern and southeastern hospital patients	Karp and Robertson, 1977

Table 11. Beryllium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Teeth	56	MS	0.01-0.97 µg/g dry wt	0.090 µg/g dry wt	Less than 20-year-old teeth	Losee, Cutress, and Brown, 1973
Urine	NG	NG	NG	0.0002 µg/ml	Normal level	Rentoul and Smith, 1973

Table 12. Bismuth

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adrenal	2 of 15	ES	<2-5 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Aorta	19 of 105	ES	<2-11 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Bladder	8	NG	10 µg/g ash	NA	Males, bismuth found in only one bladder	Koch et al., 1956
	9 of 110	ES	<2-<2 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Blood	39	XRS	0.00-0.20 ppm	NG	Males, mean age 35.3 years, serum	Gofman et al., 1964
	NG	NG	NG	0.01 µg/ml	Normal blood level, whole blood	Rentoul and Smith, 1973
Brain	NG	NG	NG	0.1 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	3 of 129	ES	<2-<2 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Diaphragm	5 of 91	ES	<2-<2 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Esophagus	6 of 68	ES	<2-<2 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Heart	NG	NG	NG	0.08 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	6 of 140	ES	<2-<2 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Intestine						
Duodenum	8 of 68	ES	<2-9 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Jejunum	16 of 104	ES	<2-10 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Ileum	12 of 84	ES	<2-9 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Cecum	8 of 31	ES	<2-43 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Sigmoid colon	14 of 109	ES	<2-5 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Rectum	6 of 42	ES	<2-11 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Kidney	NG	NG	NG	0.09 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	42 of 145	ES	<2-45 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Larynx	3 of 50	ES	<2-<2 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Liver	NG	NG	NG	0.07 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	21 of 150	ES	<2-7 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963

Table 12. Bismuth (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Lung	168	NG	<20–2600 µg (total lung)	NG	Samples from 58 cities and 29 nonurban areas	Schroeder, 1970*b*
	6 of 141	ES	<2–<2 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
	6 of 141	ES	<2–260 µg/g ash	<2 µg/g ash (median)	Autopsies, nine U.S. cities	Tipton and Shafer, 1964
Muscle	3 of 136	ES	<2–<2 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Omentum	10 of 74	ES	<2–4 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Ovary	1 of 16	ES	<2–<2 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Pancreas	13 of 139	ES	<2–<2 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Prostate	3 of 50	ES	<2–<2 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Skin	2 of 22	ES	<2–<2 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Spleen	8 of 143	ES	<2–<2 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Stomach	9 of 131	ES	<2–<2 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Teeth	56	MS	0.02–0.07 µg/g dry wt	0.006 µg/g dry wt	Less than 20-year-old teeth	Losee, Cutress, and Brown, 1973
Testis	16 of 72	ES	<2–18 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Thyroid	4 of 21	ES	<2–<2 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Total body content	163	NG	NG	0.23 mg	Samples from 58 cities and 29 nonurban areas	Schroeder, 1970*b*
Trachea	5 of 60	ES	<2–<2 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Uterus	2 of 32	ES	<2–<2 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963

Table 13. Boron

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	2	C	0-0.21 ppm	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
	1	C, ES	NG	0.074 ppm wet wt	Autopsy of 46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
Adrenal	10 of 15	ES	<10-71 µg/g ash	10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Alimentary tract	2	C	0.18-0.30 ppm	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
Aorta	3 of 105	ES	<10-<10 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Bladder	28 of 112	ES	<10-19 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Blood	1	C, ES	NG	0.141 ppm	Autopsy of 46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
	154	ES	2.0-38.0 µg/100 g	9.85 µg/100 g (median)	Adult males from various cities and farms	Imbus et al., 1963
	NG	NG	NG	0.13 µg/ml		Rentoul and Smith, 1973
Bone	1	C, ES	NG	0.9 ppm	Autopsy of 46-year-old cadaver, skeletal bone	Forbes, Cooper, and Mitchell, 1954
	2	C	0.59-0.89 ppm	NG	One white male (age 60) and one black male (age 48), skeletal bone	Forbes, Mitchell, and Cooper, 1956
Brain	NG	NG	NG	0.6 µg/g dry wt		Rentoul and Smith, 1973
	17 of 129	ES	<10-10 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Diaphragm	4 of 91	ES	<10-<10 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Esophagus	7 of 68	ES	<10-10 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Feces	2	ES	NG	0.32 ± 0.25 and 0.36 ± 0.05 mg/day	Volunteers, balance study	Tipton, Stewart, and Dickson, 1969
Gastrointestinal tract	1	C, ES	NG	0.078 ppm wet wt	Autopsy of 46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
Hair					Three New York metropolitan community samples:	Creason et al., 1975
	267	ES	0.03-22.0 µg/g	0.0881 µg/g	children	
	197	ES	0.037-25.0 µg/g	0.981 µg/g	adults	

Table 13. Boron (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	18	ES	0.0002-0.0008% dry tissue	NG	18 white males, ages 15-70 years	Goldblum, Derby, and Lerner, 1953
Heart	1	C, ES	NG	0.044 ppm wet wt	Autopsy of 46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
	2	C	0.28-0.51 ppm wet wt	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
	NG	NG	NG	0.2 µg/g dry wt		Rentoul and Smith, 1973
	11 of 140	ES	<10-<10 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Intestine						
Duodenum	16 of 68	ES	<10-14 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Jejunum	26 of 104	ES	<10-16 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Ileum	16 of 84	ES	<10-10 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Cecum	3 of 31	ES	<10-<10 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Sigmoid colon	17 of 109	ES	<10-10 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Rectum	8 of 42	ES	<10-13 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Kidney	2	C	0.17-0.46 ppm wet wt	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
	1	C, ES	NG	0.248 ppm wet wt	Autopsy of 46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
	NG	NG	NG	0.5 µg/g dry wt		Rentoul and Smith, 1973
	20 of 145	ES	<10-10 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Larynx	4 of 50	ES	<10-<10 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Liver	2	C	0.03-0.15 ppm wet wt	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
	1	C, ES	NG	0.114 ppm wet wt	Autopsy of 46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
	NG	NG	NG	0.48 µg/g dry wt		Rentoul and Smith, 1973
	37 of 150	ES	<10-10 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Lung	2	C	0.12-0.19 ppm wet wt	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956

Table 13. Boron (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	1	C, ES	NG	0.067 ppm wet wt	Autopsy of 46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
	28 of 141	ES	<10-10 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
	28 of 141	ES	<10-30 µg/g ash	<10 µg/g ash (median)	Autopsy cases, nine U.S. cities	Tipton and Shafer, 1964
Muscle	1	C, ES	NG	0.071 ppm wet wt	Autopsy of 46-year-old cadaver, striated muscle	Forbes, Cooper, and Mitchell, 1954
	2	C	0.017-0.4 ppm wet wt	NG	One white male (age 60) and one black male (age 48), striated muscle	Forbes, Mitchell, and Cooper, 1956
	6 of 137	ES	<10-<10 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Nail	18	ES	0.0007-0.0060% dry wt	NG	18 white males, ages 15-70 years	Goldblum, Derby, and Lerner, 1953
Nerve	2	C	0.0-0.1 ppm wet wt	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
	1	C, ES	NG	0.106 ppm wet wt	Autopsy of 46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
Omentum	13 of 74	ES	<10-10 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Ovary	3 of 16	ES	<10-17 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Pancreas	40 of 139	ES	<10-12 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Placenta	58	NG	NA	0.0	Southern and southeastern city hospitals	Karp and Robertson, 1977
Prostate	9 of 50	ES	<10-10 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Skin	2	C	0.34-0.45 ppm wet wt	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
	1	C, ES	NG	0.119 ppm wet wt	Autopsy of 46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
	18	ES	0.0017-0.0172% dry wt	NG	18 white males, ages 15-70 years	Goldblum, Derby, and Lerner, 1953
	8 of 22	ES	<10-24 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Spleen	1	C	NG	0.08 ppm wet wt	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956

Table 13. Boron (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	21 of 143	ES	<10-10 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Stomach	48 of 131	ES	<10-20 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Teeth	56	MS	0.5-69.0 µg/g	18.2 µg/g	Subjects less than 20 years old, wide geographic area	Losee, Cutress, and Brown, 1973
Testis	1 of 72	ES	<10-<10 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Thyroid	3 of 21	ES	<10-10 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Trachea	14 of 60	ES	<10-13 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Urine	154	ES	0-6800 µg/liter	715 µg/liter	Adult males from various cities and farms	Imbus et al., 1963
	2	ES	NG	1.2 ± 0.1 and 0.95 ± 0.08 mg/day	Volunteers, balance study	Tipton, Stewart, and Dickson, 1969
Uterus	4 of 32	ES	<10-10 µg/g ash	<10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963

Table 14. Bromine

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	NG	4.12 ppm	Males, average age 35.3 years, serum	Gofman et al., 1964
Hair	2	AAS, MS	0.17 and 1.10 µg/g dry wt	NG		Yurachek, Clemena, and Harrison, 1969
Teeth	56	MS	<0.10–2.90 µg/g	1.09 µg/g	Subjects less than 20 years old, wide geographic area	Losee, Cutress, and Brown, 1973

Table 15. Cadmium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adrenal	11 of 15	ES	<50-150 µg/g ash	50 µg/g ash (median)	Adults	Tipton and Cook, 1963
Aorta	46	AAS	<0.2-12.3 µg/g dry wt	0.3-5.5 µg/g dry wt	Autopsies, Chicago area	Marks et al., 1972
	100	ES	<0.4-1.3 micromoles/g ash	NG	Adults	Perry, 1968
	19 of 105	ES	<50-60 micromoles/g ash	<50 micromoles/g ash (median)	Adults	Tipton and Cook, 1963
Bladder	34 of 112	ES	<50-66 µg/g ash	<50 µg/g ash (median)	Adults, urinary bladder	Tipton and Cook, 1963
Blood	83	AAS	NG	0.93 ± 0.115 µg/g dry wt	Nashville, Tennessee, hospitals, maternal blood	Baglan et al., 1974
	123	AAS	NG	0.076 ± 0.109 µg/g dry wt	Nashville, Tennessee, hospitals, fetal blood	Baglan et al., 1974
	259	AAS	NG	0.20 µg/100 ml (mean) 0.19 µg/100 ml (median)	Children in nonsmelter towns	Baker et al., 1977
	119	AAS	NG	0.21 µg/100 ml (mean) 0.15 µg/100 ml (median)	Children in lead smelter towns	Baker et al., 1977
	338	AAS	NG	0.30 µg/100 ml (mean) 0.19 µg/100 ml (median)	Children in zinc smelter towns	Baker et al., 1977
	520	AAS	NG	1.2 ± 1.1 to 16.4 ± 6.3 µg/liter	Kansas City, Missouri, and Kansas City, Kansas, soft and hard water areas, respectively, serum	Bierenbaum et al., 1975
	369	AAS	0.0-2.8 µg/100 ml	0.3 µg/100 ml	Newark, New Jersey, children 1-8 years old	Bogden, Singh, and Joselow, 1974
	47	ES	NG	0.209 ± 0.005 mg/100 ml	Normal Los Angeles residents	Butt et al., 1964
	266	ES	NG	0.034 ± 0.002 to 0.048 ± 0.001 mg/100 ml	Los Angeles residents — blood donors, surgical patients, diseased and normal individuals, serum	Butt et al., 1964
	39	XRS	0.00-0.23 ppm	NG	Men, mean age 35.3 years, serum	Gofman et al., 1964
	40	AAS	0.42 ± 0.7 µg/100 ml	NG	Lumberyard workers in vicinity of fertilizer plant, plasma	Hammer, Finklea, Creason, Sandifer, Keil, Priester, and Stara, 1971
	100	ASV	<0.1-9.6 µg/100 ml	1.71 µg/100 ml	18- to 58-year-old Ann Arbor, Michigan, residents	Hecker et al., 1974

Table 15. Cadmium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	154	ES	0.3-5.4 µg/100 g	0.70 µg/100 g (median)	Men	Imbus et al., 1963
	216	AAS	NG	0.4 ± 0.44 to 0.9 ± 1.1 µg/100 ml		Johnson, Tillery, and Prevost, 1975b
	243	AAS	0.50-14.16 µg/100 ml	1.77 µg/100 ml	19 cities	Kubota, Lazar, and Losee, 1968
	60	AAS	0.22-1.70 µg/100 g	0.66 µg/100 g	Children, 2 months to 13 years old, white, middle and upper class	Smith, 1976
	355	AAS	0.04-1.77 µg/100 ml	0.12 µg/100 ml	250 people live in vicinity of cadmium smelter	Wysowski et al., 1978
Brain	36	AAS	0.0-0.144 µg/g wet wt	0.140 µg/g wet wt	Fetuses	Chaube, Nishimura, and Swinyard, 1973
	8	ES	NG	Trace, ppm wet wt	Males	Koch et al., 1956
	NG	NG	NG	2.55 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	0 of 129	ES	<50-<50 µg/g ash	<50 µg/g ash (median)	Not found within detection limits, adults	Tipton and Cook, 1963
Diaphragm	6 of 91	ES	<50-<50 µg/g ash	<50 µg/g ash (median)	Adults	Tipton and Cook, 1963
Esophagus	1	ES	NG	Trace	Males	Koch et al., 1956
	4 of 68	ES	<50-<50 µg/g ash	<50 µg/g ash (median)	Adults	Tipton and Cook, 1963
Feces	216	AAS	NG	0.19 ± 0.07 to 0.30 ± 0.21 µg/g	Controls included	Johnson, Tillery, and Prevost, 1975b
	2	AAS	NG	0.030 ± 0.008 mg/day 0.047 ± 0.007 mg/day	Volunteers, balance study	Tipton, Stewart, and Dickson, 1969
Hair	160	AAS	NG	0.93 µg/g (mean) 0.51 µg/g (median)	Children in nonsmelter towns	Baker et al., 1977
	126	AAS	NG	5.34 µg/g (mean) 3.55 µg/g (median)	Children in lead smelter towns	Baker et al., 1977
	872	AAS	NG	1.88 µg/g (mean) 1.44 µg/g (median)	Children in copper smelter towns	Baker et al., 1977
	295	AAS	NG	5.57 µg/g (mean) 2.91 µg/g (median)	Children in zinc smelter towns	Baker et al., 1977
	482	AAS	0.14-6.90 µg/g 0.08-8.73 µg/g	0.88 µg/g 0.76 µg/g	Three New York suburbs: 281 children 201 adults	Creason et al., 1975

Table 15. Cadmium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	50	AAS	0.1-9.3 ppm	1.0 ppm 2.2 ppm	25 women 25 men	Eads and Lambdin, 1973
	168	AAS	0.0-10.5 ppm	0.9-3.5 ppm	Fourth-grade boys from five U.S. cities	Hammer, Finklea, Creason, Sandifer, Keil, Priester, and Stara, 1971
	12	AAS	0.6-6.9 µg/g	2.3 µg/g	Males and females, various ages	Hinners et al., 1974
	216	AAS	NG	0.6 ± 0.41 to 2.2 ± 2.10 µg/g	Controls included in case studies	Johnson, Tillery, and Prevost, 1975*b*
	220	AAS	NG	1.98 ± 0.14 ppm ash	Mean only for men, 220 cases include some occupationally exposed men and women	Oleru, 1975
	50	AAS	30.60-530.47 ppm ash	158.38 ppm ash	Correlation with age studied, mean age — 54	Oleru, 1976
	178	AAS	0.8-2.0 ppm	NG	95 males, ages 2-88 and 83 females, ages 14-84	Petering, Yeager, and Witherup, 1973
	129	AAS	NG	2.76 ± 0.48 µg/g 1.77 ± 0.24 µg/g	82 males 47 females	Schroeder and Nason, 1969
	1	AAS	1.92 ± 0.02 µg/g	NA		Sorenson et al., 1973
	2	AAS, MS	0.34 and 0.96 µg/g dry wt	NA		Yurachek, Clemens, and Harrison, 1969
Heart	100	ES	0.4-1.3 micromoles/g ash	NG	Adults	Perry, 1968
	NG	NG	NG	3.34 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	3 of 140	ES	<50-<50 µg/g ash	<50 µg/g ash (median)	Adults	Tipton and Cook, 1963
Intestine	7	ES	NG	0.6 ppm wet wt	Males, small intestine	Koch et al., 1956
Duodenum	38 of 68	ES	<50-85 µg/g ash	50 µg/g ash (median)	Adults	Tipton and Cook, 1963
Jejunum	60 of 104	ES	<50-100 µg/g ash	50 µg/g ash (median)	Adults	Tipton and Cook, 1963
Ileum	21 of 84	ES	<50-60 µg/g ash	<50 µg/g ash (median)	Adults	Tipton and Cook, 1963
Cecum	5 of 31	ES	<50-50 µg/g ash	<50 µg/g ash (median)	Adults	Tipton and Cook, 1963
Sigmoid colon	25 of 109	ES	<50-60 µg/g ash	<50 µg/g ash (median)	Adults	Tipton and Cook, 1963
Rectum	5 of 42	ES	<50-50 µg/g ash	<50 µg/g ash (median)	Adults	Tipton and Cook, 1963
Kidney	36	AAS	0.0-0.062 µg/g wet wt	0.05 µg/g wet wt	Fetuses	Chaube, Nishimura, and Swinyard, 1973

Table 15. Cadmium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	120	AAS	21-4771 ppm ash wt	1500 ppm ash wt	Autopsies, black and white, cortex: 14 cases, 4-6 years old; 106 cases, 16-19 years old	Hammer et al., 1973
	24	AAS				
			400-5500 µg/g ash	1700 µg/g ash	Autopsies: control (12)	Hirst et al., 1973
			690-5300 µg/g ash	3000 µg/g ash	emphysema cadavers (12)	
	6	ES	NG	25 ppm wet wt	Male accident victims	Koch et al., 1956
	10	ES	17.5-311.4 µg/g dry wt	ND	Six normal patients	Koch, Smith, and McNelly, 1957
			4.0-93.2 µg/g dry wt	ND	Four diseased patients	
	160	AAS	NG	14.8 ± 1.86 µg/g wet wt	Nonsmokers	Lewis et al., 1972
			NG	31.1 ± 1.63 µg/g wet wt	Smokers	
	1	NAA	185-460 ppm dry wt	NA	Four samples	Lieberman and Kramer, 1970
	38	NAA				
			0.04-0.29 µg/g dry wt	0.14 ± 0.10 µg/g dry wt	Autopsies, cortex: 6 children	Livingstone, 1971
			16-305 µg/g dry wt	104 ± 73 µg/g dry wt	32 adults	
	80	AAS	795-7550 µg/g ash	2467 µg/g ash	Control (traumatic or infectious diseases)	Morgan, 1969
			995-3785 µg/g ash	2527 µg/g ash	Chronic hypertensives	
			899-3802 µg/g ash	2240 µg/g ash	Cardiac or cerebrovascular disease	
			719-9832 µg/g ash	3624 µg/g ash	Malignant disease	
	104	AAS	NG	2512 ± 1427 µg/g ash	Control (35 males and 1 female)	Morgan, Burch, and Watkins, 1971
				2921 ± 1252 to 2478 ± 1639 µg/g ash	Emphysematic and cancerous lung patients (all male)	
	100	AAS	109-9832 µg/g ash	2539 µg/g ash	Autopsies: 32 blacks, 68 whites, 99 men; whites higher	Morgan, 1972*b*
	50	AAS	602.56-5350.51 ppm ash	1548.82 ppm ash		Oleru, 1976
	157	ES	0-4300 µg/g ash	0-2150 µg/g ash	St. Louis children and adults, age correlation	Perry et al., 1961
	150	ES	13-45 micromoles/g ash	NG	St. Louis adults	Perry et al., 1962
	134	ES	NG	2940 ± 120 µg/g ash	Accident victims (117)	Perry, 1968
				4220 ± 390 µg/g ash	Hypertensives (17)	
	24	AAS	NG	1720 ± 1470 µg/g ash	Control patients (12)	Perry et al., 1972
				2950 ± 1340 µg/g ash	Emphysematic patients (12)	

Table 15. Cadmium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	NG	NG	NG	66.4 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	187	ES	NG	2660 ± 270 to 4220 ± 390 ppm ash	Adults, accidental deaths, ten cities, hypertensive cases highest	Schroeder, 1965
	145	ES	1500-5100 µg/g ash	2900 µg/g ash	Adults	Tipton and Cook, 1963
Larynx	1 of 50	ES	<50-<50 µg/g ash	<50 µg/g ash (median)	Adults	Tipton and Cook, 1963
Liver	36	AAS	0.0-0.133 µg/g wet wt	0.114 µg/g wet wt	Fetuses	Chaube, Nishimura, and Swinyard, 1973
	120	AAS	8-1720 ppm ash wt	180 ppm ash wt	Autopsies, black and white: 14 cases, 4-6 years old; 106 cases, 16-91 years old	Hammer et al., 1973
	24	AAS	14-150 µg/g ash 19-530 µg/g ash	63-230 µg/g ash	Control (12) Emphysematic (12)	Hirst et al., 1973
	5	ES	NG	4 ppm wet wt	Male accident victims	Koch et al., 1956
	8	ES			Five normal and three diseased patients: mean — normal patients range — normal and diseased patients	Koch, Smith, and McNelly, 1957
			4.1-32.6 µg/g dry wt 1.9-6.7 µg/g dry wt	15.1 µg/g dry wt		
	161	AAS	NG	1.38 ± 0.24 µg/g wet wt 2.05 ± 0.12 µg/g wet wt	Nonsmokers Smokers	Lewis et al., 1972
	80	AAS	51-440 µg/g ash	171 µg/g ash	Control (traumatic or infectious diseases)	Morgan, 1969
			66-489 µg/g ash	204 µg/g ash	Chronic hypertensives	
			69-397 µg/g ash	182 µg/g ash	Cardiac or cerebrovascular disease patients	
			28-3293 µg/g ash	304 µg/g ash	Malignant disease patients	
	104	AAS	NG	170 ± 95 µg/g ash	Control (35 males and 1 female)	Morgan, Burch, and Watkins, 1971
				249 ± 142 to 290 ± 155 µg/g ash	Emphysematic and cancerous lung patients (all male)	
	50	AAS	31.20-414.95 ppm	104.83 ppm		Oleru, 1976
	157	ES	0-2000 µg/g ash	0-335 µg/g ash	St. Louis children and adults, age correlations	Perry et al., 1961
	100	ES	<0.4-6.7 micromoles/g ash	NG	Adults	Perry, 1968
	150	ES	0.53-3.0 micromoles/g ash	NG	St. Louis adults	Perry et al., 1972

Table 15. Cadmium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	24	AAS	NG	61.4 ± 37.3 µg/g ash 228 ± 188 µg/g ash	Control (12) Emphysematic individuals (12)	Perry et al., 1972
	10	ES	NG	310 ± 140 µg/g ash	St. Louis males, five black and five white	Perry et al., 1973
	NG	NG	NG	6.38 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	NG	ES	0-2 mg/100 g dry wt	NG	Cancer patients and autopsy specimens	Tietz, Hirsch, and Heyman, 1957
	146 of 150	ES	60-340 µg/g ash	180 µg/g ash (median)	Adults	Tipton and Cook, 1963
	90	AAS			Over 30-year period:	Voors and Shuman, 1977
			71-1720 ppm ash	288 ppm ash (geometric mean)	heart disease (28 cases)	
			21-1000 ppm ash	139 ppm ash (geometric mean)	other individuals	
Lung	24	AAS	2.2-48 µg/g ash 20-230 µg/g ash	19 µg/g ash 83 µg/g ash	Control (12) Emphysematics (12)	Hirst et al., 1973
	3	ES	NG	2 ppm wet wt	Male accident victims	Koch et al., 1956
	153	AAS	NG	0.33 ± 0.04 µg/g wet wt 0.56 ± 0.03 µg/g wet wt	Nonsmokers Smokers	Lewis et al., 1972
	1	NAA	3.5-4.9 ppm dry wt	NG	Three samples	Lieberman and Kramer, 1970
	50	AAS	10.80-143.45 ppm ash wt	38.93 ppm ash wt		Oleru, 1976
	150	ES	<0.4-0.89 micromole/g ash	NG	St. Louis adults	Perry et al., 1962
	100	ES	0.4-1.3 micromoles/g ash	NG	Adults	Perry, 1968
	24	AAS	NG	19.6 ± 13.4 µg/g ash 83.5 ± 58.3 µg/g ash	Normal men (12) Emphysematic men (12)	Perry et al., 1972
	168	NG	58-930 µg/g	NG	Autopsies from 58 cities and 29 rural areas	Schroeder, 1970*b*
	NG	ES	0-1.0 mg/100 g dry wt	NG	Cancer patients and autopsy specimens	Tietz, Hirsch, and Heyman, 1957
	71 of 141	ES	<50-100 µg/g ash	<50 µg/g ash (median)	Adults	Tipton and Cook, 1963
	71 of 141	ES	<50-270 µg/g ash	<50 µg/g ash (median)	Autopsy cases, nine U.S. cities	Tipton and Shafer, 1964
Milk	14	AAS	0.0088-0.1335 ppm	0.0111 ppm	12-week breast feeding average	Pinkerton et al., 1972

Table 15. Cadmium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Muscle	6	ES	NG	0.2 ppm wet wt	Males	Koch et al., 1956
	1	NAA	0.27-1.00 ppm dry wt	NG	Five samples	Lieberman and Kramer, 1970
	3 of 137	ES	<50-<50 µg/g ash	<50 µg/g ash (median)	Adults	Tipton and Cook, 1963
Myocardium	26	AAS	<0.2-4.0 µg/g dry wt	0.4-1.9 µg/g dry wt	Autopsies, Chicago area	Marks et al., 1972
Omentum	31 of 74	ES	<50-100 µg/g ash	<50 µg/g ash (median)	Adults	Tipton and Cook, 1963
Ovary	5 of 16	ES	<50-78 µg/g ash	<50 µg/g ash (median)	Adults	Tipton and Cook, 1963
Pancreas	120 of 139	ES	<50-200 µg/g ash	80 µg/g ash (median)	Adults	Tipton and Cook, 1963
	2	ES	NG	2 ppm wet wt	Males	Koch et al., 1956
Placenta	554	AAS	NG	0.27 ± 0.10 to 0.63 ± 0.15 micromole/g tissue wt	12-month study	Dawson et al., 1968
	554	AAS	NG	0.48 ± 0.43 micromole/g dry wt	Houston women, normal births	Dawson et al., 1969
	58	NG	NG	0.037 ± 0.003 µg/g wet wt	Southern and southeastern city hospitals	Karp and Robertson, 1977
Prostate	4	ES	NG	0.2 ppm wet wt	Males	Koch et al., 1956
	20 of 50	ES	<50-95 µg/g ash	<50 µg/g ash (median)	Adults	Tipton and Cook, 1963
Skin	0 of 22	ES	<50-<50 µg/g ash	<50 µg/g ash (median)	Adults	Tipton and Cook, 1963
Spleen	3	ES	NG	0.3 ppm wet wt	Males	Koch et al., 1956
	3	ES	ND – 2.2 µg/g dry wt	0.7 µg/g dry wt	Normal individuals	Koch, Smith, and McNelly, 1957
	26	AAS	0.1-3.8 µg/g dry wt	0.6-1.8 µg/g dry wt	Autopsies, Chicago area	Marks et al., 1972
	150	ES	<0.4-0.44 micromole/g ash	NG	St. Louis adults	Perry et al., 1962
	100	ES	<0.4-1.1 micromoles/g ash	NG	Adults	Perry, 1968
	18 of 143	ES	<50-50 µg/g ash	<50 µg/g ash (median)	Adults	Tipton and Cook, 1963
Stomach	4	ES	NG	0.4 ppm wet wt	Males	Koch et al., 1956
	49 of 131	ES	<50-80 µg/g ash	<50 µg/g ash (median)	Adults	Tipton and Cook, 1963

Table 15. Cadmium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Teeth	56	MS	0.03-6.70 μg/g dry wt	0.99 ± 0.15 μg/g dry wt	Less than 20-year-old teeth, enamel	Losee, Cutress, and Brown, 1973
Testis	1	MS	NG	0.4 ppm wet wt	Males	Koch et al., 1956
	11 of 72	MS	<50-50 μg/g ash	<50 μg/g ash (median)	Adults	Tipton and Cook, 1963
Thyroid	2	MS	NG	0.8 ppm wet wt	Males	Koch et al., 1956
	14 of 21	MS	<50-190 μg/g ash	50 μg/g ash (median)	Adults	Tipton and Cook, 1963
Total body content	NG	NG	NG	50 mg		Schroeder, 1970*b*
Trachea	7 of 60	MS	<50-50 μg/g ash	<50 μg/g ash (median)	Adults	Tipton and Cook, 1963
Urine	40	AAS	NG	1.04 μg/liter	Lumberyard workers near fertilizer plant	Hammer, Finklea, Creason, Sandifer, Keil, Priester, and Stara, 1971
	154	ES	0.4-3.0 μg/liter	1.15 μg/liter	Men	Imbus et al., 1963
	216	AAS	NG	0.5 ± 0.23 to 1.4 ± 1.05 μg/liter	Six groups, 36 each	Johnson, Tillery, and Prevost, 1975*b*
	38	ES	NG	0.75 ppb 40 ppb 6 ppb	Normal (15) Hypertensive (15) Treated hypertensives (8)	Perry, 1968
	32	ES	<7-22 μg/liter	<12.7 μg/liter <13.0 μg/liter	Black and white men, black and white females: range — 24 normal individuals mean — 24 normals and 8 cholesterolemic patients	Perry and Perry, 1959
	2	AAS	NG	0.083 ± 0.005 mg/day 0.092 ± 0.005 mg/day	Volunteers, balance study	Tipton, Stewart, and Dickson, 1969
	43	AAS	<0.04-0.81 μg/100 ml <0.04-1.11 μg/100 ml <0.04-0.94 μg/100 ml	0.14 μg/100 ml 0.34 μg/100 ml 0.21 μg/100 ml	Distance from cadmium smelter: 1 km 1-2 km 13 km	Wysowski et al., 1978
Uterus	5 of 32	ES	<50-50 μg/g ash	<50 μg/g ash (median)	Adults	Tipton and Cook, 1963
Vena cava	1	ES	NG	Trace	Males	Koch et al., 1956

Table 16. Cerium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00-0.55 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964
Teeth	56	MS	0.02-0.19 µg/g dry wt	0.070 µg/g dry wt	Subjects less than 20 years old, wide geographic area, enamel	Lowe, Cutress, and Brown, 1973

Table 17. Cesium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00–0.52 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964
Teeth	56	MS	0.02–0.10 µg/g dry wt	0.04 µg/g dry wt	Subjects less than 20 years old, wide geographic area, enamel	Losee, Cutress, and Brown, 1973

Table 18. Chromium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adrenal	13	ES	2.0–16.0 µg/g ash	9.4 µg/g ash (median)		Tipton and Cook, 1963
Aorta	150	ES	0.002–0.190 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	150	C	0.0–19.5 µg/g ash	NG	High levels in children, especially infants	Schroeder, Balassa, and Tipton, 1962a
	90 of 103	ES	<0.1–10.0 µg/g ash	2.0 µg/g ash (median)		Tipton and Cook, 1963
Bladder	2	ES	NG	0.2 ppm wet wt	Sudden accident victims, normal	Koch et al., 1956
	103 of 110	ES	0.4–13.0 µg/g ash	3.4 µg/g ash (median)		Tipton and Cook, 1963
Blood	520	AAS			Blood serum:	Bierenbaum et al., 1975
			NG	0.012 ± 0.002 mg/liter	one-half samples in soft-water area	
			NG	0.043 ± 0.007 mg/liter	one-half in hard-water area	
	5	GC	3.48–9.67 ng/g	NG	Blood plasma	Black and Sievers, 1976
	116	ES	NG	0.0015–0.0135 mg/100 ml	Patients and normal individuals, Los Angeles, serum	Butt et al., 1964
	39	XRS	0.00–0.04 ppm	NG	Healthy males, mean age 35.3 years, blood serum	Gofman et al., 1964
	154	ES	1.0–6.0 µg/g	2.65 µg/g	Adult males from cities and farms	Imbus et al., 1963
	17	ES	0.7–5.2 µg/100 ml	2.2 µg/100 ml	Sudden accident victims, normal	Koch et al., 1956
	NG	NG	0.5–5.0 µg/liter	NG		Mertz, 1974
Brain	3	ES	NG	0.28 ppm wet wt	Sudden accident victims, normal	Koch et al., 1956
	150	ES	0.002–0.038 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	84 of 128	ES	<0.1–2.0 µg/g ash	0.2 µg/g ash	U.S. adults	Tipton and Cook, 1963
Diaphragm	90 of 91	ES	0.4–6.4 µg/g ash	2.3 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Esophagus	63 of 66	ES	0.8–11.0 µg/g ash	3.0 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Feces	2	ES	NG	0.078 ± 0.013 mg/day 0.092 ± 0.014 mg/day	Volunteers, balance study	Tipton, Stewart, and Dickson, 1969

Table 18. Chromium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Hair						
	261	ES	0.06–5.30 µg/g	0.56 µg/g	Three New York metropolitan community samples: children	Creason et al., 1975
	192	ES		0.62 µg/g	adults	
	101	ES	NG	1061 ppb	Newborns	Hambidge and Baum, 1972
				350 ppb	1 year olds	
				331 ppb	3 to 40 year olds	
	21	AAS	0.20–2.81 and 0.04–1.14 µg/g	0.75 and 0.22 µg/g	Values from age 20–40 years	Hambidge and Rodgerson, 1969
	47	ES	52–692 ppb	NG	Normal children and young adults ages 4–32 years	Hambidge, Franklin, and Jacobs, 1972
	10	NAA	0.530 ± 0.138 ppm	NG		Obrusnik et al., 1972
	181	AAS	NG	0.70 ± 0.06 µg/g	Low value for males and high value for females aged 10 months to 102 years; none dyed or bleached	Schroeder and Nason, 1969
				0.96 ± 0.05 µg/g		
	2	MS	0.65 and 5.9 µg/g dry wt	NG		Yurachek, Clemena, and Harrison, 1969
Heart	150	ES	0.002–0.160 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	150	C	0.0–82.4 µg/g ash	NG	High levels in children, especially infants	Schroeder, Balassa, and Tipton, 1962a
	125 of 140	ES	<0.1–8.2 µg/g ash	1.5 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Intestine						
	1	ES	NG	0.5 ppm wet wt	Sudden accident victims, normal: large intestine	Koch, Smith, and McNelly, 1956
	7	ES	NG	1.2 ppm wet wt	small intestine	
Duodenum	63 of 67	ES	0.4–6.4 µg/g ash	2.3 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Jejunum	88 of 101	ES	<0.1–6.4 µg/g ash	1.7 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Ileum	80 of 84	ES	0.5–12.0 µg/g ash	4.0 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Cecum	31	ES	1.7–20.0 µg/g ash	6.2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Sigmoid colon	101 of 108	ES	0.5–16.0 µg/g ash	3.9 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Rectum	42	ES	1.1–13.0 µg/g ash	4.1 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Kidney	5	ES	0.0–2.9 µg/g dry wt	1.2 µg/g dry wt	Normal subjects	Koch, Smith, and McNelly, 1957

Table 18. Chromium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	5	ES	NG	0.16 ppm wet wt	Sudden accident victims, normal	Koch et al., 1956
	150	ES	0.002-0.087 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	150	C	2.0-57.5 µg/g ash	NG	High levels in children, especially infants	Schroeder, Balassa, and Tipton, 1962a
	NG	ES	0.0-1.0+ mg/100 g dry wt	NG		Tietz, Hirsch, and Neyman, 1957
	117 of 142	ES	<0.1-4.5 µg/g ash	1.0 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
	27 of 49	ES	<0.1-6.0 µg/g ash	0.1 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Larynx	4	ES	0.0-11.3 µg/g dry wt	3.3 µg/g dry wt	Normal subjects	Koch, Smith, and McNelly, 1957
Liver	4	ES	NG	1.5 ppm wet wt	Sudden accident victims, normal	Koch et al., 1956
	104	AAS	NG NG NG NG	16.0 µg/g ash 14.6 µg/g ash 9.5 µg/g ash 9.2 µg/g ash	Males: normals emphysema emphysema/cancer cancer patients	Morgan, 1972a
	150	ES	0.002-0.071 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	10	ES	NG	1.38 ± 1.24 µg/g ash	Five white and five black male accident victims, long-term residents of St. Louis	Perry et al., 1973
	150	C	1.1-17.9 µg/g ash	NG	High levels in children, especially infants	Schroeder, Balassa, and Tipton, 1962a
	NG	ES	0.0-1.0+ mg/g dry wt	NG		Tietz, Hirsch, and Neyman, 1957
	115 of 146	ES	<0.1-3.7 µg/g ash	0.7 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Lung	3	ES	1.8-9.6 µg/g dry wt	3.7 µg/g dry wt	Normal subjects	Koch, Smith, and McNelly, 1957
	3	ES	NG	0.6 ppm wet wt	Sudden accident victims, normal	Koch et al., 1956
	150	ES	0.063-0.95 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962

Table 18. Chromium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	168	NG	NG	Min — 5.0 µg, max — 2000 µg, and retained per year — 4.0 µg	Autopsy samples from 58 cities and 29 nonurban areas	Schroeder, 1970*a*
	150	C	1.1–85.2 µg/g ash	NG	High levels in children, especially infants	Schroeder, Balassa, and Tipton, 1962*a*
	NG	ES	0.0–1.0+ mg/100 g dry wt	NG		Tietz, Hirsch, and Neyman, 1957
	139	ES	3.4–50.0 µg/g ash	13.0 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
	139	ES	0.5–120 µg/g ash	20 µg/g ash	Autopsy cases, nine U.S. cities	Tipton and Shafer, 1964
Muscle	7	ES	NG	0.1 ppm wet wt	Sudden accident victims, normal	Koch et al., 1956
	120 of 136	ES	<0.1–5.0 µg/g ash	1.0 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Omentum	75	ES	2.3–32.0 µg/g ash	12.0 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Ovary	16	ES	0.7–150.0 µg/g ash	2.2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Pancreas	3	ES	NG	0.3 ppm wet wt	Sudden accident victims, normal	Koch et al., 1956
	150	C	0.9–6.5 µg/g ash	NG	High levels in children, especially infants	Schroeder, Balassa, and Tipton, 1962*a*
	122 of 139	ES	<0.1–6.8 µg/g ash	1.6 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Placenta	58	NG	NG	0.145 ± 0.090 µg/g wet wt		Karp and Robertson, 1977
Prostate	4	ES	NG	0.2 ppm wet wt	Sudden accident victims, normal	Koch et al., 1956
	41 of 50	ES	<0.1–6.0 µg/g ash	0.9 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Skin	22	ES	9.0–86 µg/g ash	17 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Spleen	2	ES	NG	1.4 µg/g dry wt	Normal subjects	Koch, Smith, and McNelly, 1957
	2	ES	NG	0.3 ppm wet wt	Sudden accident victims, normal	Koch et al., 1956
	150	ES	0.002–0.062 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962

Table 18. Chromium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	150	C	0.3–27.0 µg/g ash	NG	High levels in children, especially infants	Schroeder, Balassa, and Tipton, 1962*a*
	113 of 143	ES	<0.1–3.2 µg/g ash	0.5 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Stomach	3	ES	NG	0.35 ppm wet wt	Sudden accident victims, normal	Koch et al., 1956
	118 of 130	ES	0.1–6.6 µg/g ash	2.0 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Teeth	56	MS	<1.0–31.0 µg/g	2.30 ± 0.69 µg/g	Subjects less than 20 years old, wide geographic area	Lowee, Cutress, and Brown, 1973
Testis	1	ES	NG	0.2 ppm wet wt	Sudden accident victims, normal	Koch et al., 1956
	150	C	1.0–3.6 µg/g ash	NG	High levels in children, especially infants	Schroeder, Balassa, and Tipton, 1962*a*
	66 of 72	ES	0.1–6.3 µg/g ash	1.6 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Thyroid	2	ES	NG	1.3 ppm wet wt	Sudden accident victims	Koch et al., 1956
	18 of 21	ES	<0.1–5.0 µg/g ash	1.5 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Total body content		NG	NG	1.8 mg	U.S. autopsy samples	Schroeder, 1970*a*
Trachea	53 of 60	ES	0.1–8.8 µg/g ash	3.4 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Urine	NG	NAA	NG	0.026 mg/liter	Normal subjects	Gills et al., 1974
	154	ES	1.5–11.5 µg/liter	3.77 µg/liter	Adult men from various cities and farms	Imbus et al., 1963
	38	ES	NG	1.0 ppb 2.3–3.0 ppb	Normals Hypertensive patients	Perry, 1968
	2	ES	NG	0.11 ± 0.01 mg/day 0.12 ± 0.01 mg/day	Volunteers, balance study	Tipton, Stewart, and Dickson, 1969
Uterus	28 of 32	ES	<0.1–10.0 µg/g ash	1.6 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963

Table 19. Cobalt

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	2	Ch	0.010–0.012 ppm	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
	1	C	NG	0.008 ppm wet wt	46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
	1	ES	NG	1.24 µg/g wet wt		Schroeder, Nason, and Tipton, 1967
Adrenal	1	NAA	NG	0.1 ppm wet wt	Accident victims, age 56 years old or less	Koch et al., 1956
	6 of 14	ES	<2–11 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Alimentary tract	2	Ch	0.017–0.025 ppm wet wt	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
Aorta	1	ES	NG	0.40 µg/g wet wt	Autopsies	Schroeder, Nason, and Tipton, 1967
	21 of 104	ES	<2–6 µg/g ash	<2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Bladder	1	NAA	NG	0.04 ppm wet wt	Sudden accident victims, age 56 years old or less	Koch et al., 1956
	1	ES	NG	<0.06 µg/g wet wt	Autopsy	Schroeder, Nason, and Tipton, 1967
	12 of 110	ES	<2–2 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Blood	520	AAS	NG	0.00 ± 0.00 mg/liter	Serum: one-half sample from hard-water area, Kansas	Bierenbaum et al., 1975
			NG	0.146 ± 0.026 mg/liter	one-half sample from soft-water area, Missouri	
	48	ES	0.0061–0.0063 mg/100 ml	NG	Los Angeles area: serum	Butt et al., 1964
	48	ES	NG	0.0238 mg/ml	whole blood	
	39	XRS	0.00–0.05 ppm	NG	Males, mean age 35.3 years	Gofman et al., 1964
Bone	2	Ch	0.026–0.031 ppm wet wt	NG	One white male (age 60) and one black male (age 48), skeleton	Forbes, Mitchell, and Cooper, 1956
	1	C	NG	0.038 ppm wet wt	46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
	121	AAS	11.0–22.9 µg/g dry wt	16.9 ± 6.01 µg/g dry wt	40 normal, 81 osteogenic sarcomas	Janes, McCall, and Elveback, 1972

Table 19. Cobalt (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	1	NAA	NG	0.03 ppm wet wt	Sudden accident victim	Koch et al., 1956
Brain	1	NAA	NG	0.02 ppm wet wt	Sudden accident victim	Koch et al., 1956
	2	ES	0.05–0.37 µg/g wet wt	NG	Autopsies	Schroeder, Nason, and Tipton, 1967
	2 of 129	ES	<2–<2 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Diaphragm	1	ES	NG	0.14 µg/g wet wt	Autopsy	Schroeder, Nason, and Tipton, 1967
	5 of 91	ES	<2–<2 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Esophagus	2	NAA	NG	0.025 ppm wet wt	Sudden accident victims	Koch et al., 1956
	5 of 67	ES	<2–<2 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Feces	2	ES	NG	0.034 ± 0.006 and 0.059 ± 0.008	Volunteers, balance study	Tipton, Stewart, and Dickson, 1969
Gastrointestinal tract	1	C	NG	0.008 ppm wet wt	46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
Hair	10	NAA	NG	0.084 ± 0.009 ppm		Obrusnik et al., 1972
	126	AAS	NG	0.17 ± 0.02 µg/g	Males, age 10 months to 102 years, scalp hair	Schroeder and Nason, 1969
	55	AAS	NG	0.28 ± 0.04 µg/g	Females, age 10 months to 102 years, scalp hair	Schroeder and Nason, 1969
	2	MS, AAS	0.24–0.34 µg/g	NG		Yurachek, Clemena, and Harrison, 1969
Heart	2	Ch	0.033–0.035 ppm wet wt	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
	1	C	NG	0.032 ppm wet wt	46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
	2	ES	0.16–0.23 µg/g wet wt	NG	Autopsies	Schroeder, Nason, and Tipton, 1967
	39 of 140	ES	<2–5 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Intestine	5	NAA	NG	0.05 ppm wet wt	Sudden accident victims	Koch et al., 1956
Ileum	1	ES	NG	0.08 µg/g wet wt	Autopsy	Schroeder, Nason, and Tipton, 1967

Table 19. Cobalt (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Jejunum	2	ES	0.04-0.17 µg/g wet wt	NG	Autopsy	Schroeder, Nason, and Tipton, 1967
Sigmoid colon	1	ES	NG	0.01 µg/g wet wt	Autopsy	Schroeder, Nason, and Tipton, 1967
Cecum	10 of 31	ES	<2-8 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Ileum	18 of 83	ES	<2-10 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Duodenum	6 of 67	ES	<2-<2 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Jejunum	7 of 102	ES	<2-<2 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Sigmoid colon	21 of 108	ES	<2-11 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Rectum	10 of 42	ES	<2-11 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Kidney	2	Ch	0.032-0.037 ppm wet wt	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
	2	NAA	NG	0.64 ppm wet wt	Sudden accident victims	Koch et al., 1956
	3	ES	0.05-0.11 µg/g wet wt	NG	Autopsies	Schroeder, Nason, and Tipton, 1967
	21 of 144	ES	<2-2 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Larynx	3 of 50	ES	<2-<2 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Liver	2	Ch	0.064-0.126 ppm wet wt	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
	1	C	NG	0.056 ppm wet wt	46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
	2	NAA	NG	0.25 ppm wet wt	Sudden accident victims	Koch et al., 1956
	10	ES	NG	8.58 ± 5.55 µg/g ash	Five white and five black males, accident victims	Perry et al., 1973
	2	ES	0.12-0.28 µg/g wet wt	NG	Autopsies	Schroeder, Nason, and Tipton, 1967
	63 of 149	ES	<2-10 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Lung	2	Ch	0.028-0.039 ppm wet wt	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
	1	C	NG	0.018 ppm wet wt	46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954

Table 19. Cobalt (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	169	NG	<20-1400 µg/g	NG	Autopsies from 58 cities and 29 nonurban areas	Schroeder, 1970*b*
	2	ES	0.06-0.13 µg/g wet wt	NG	Autopsies	Schroeder, Nason, and Tipton, 1967
	26 of 141	ES	<2-9 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
	26 of 141	ES	<2-140 µg/g ash	<2 µg/g ash (median)	Autopsies, nine U.S. cities	Tipton and Shafer, 1964
Muscle	2	Ch	0.006-0.008 ppm wet wt	NG	One white male (age 60) and one black male (age 48), striated muscle	Forbes, Mitchell, and Cooper, 1956
	1	C	NG	0.006 ppm wet wt	46-year-old cadaver, striated muscle	Forbes, Cooper, and Mitchell, 1954
	4	NAA	NG	0.05 ppm wet wt	Sudden accident victims	Koch et al., 1956
	6 of 136	ES	<2-<2 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Nerve	2	Ch	NG	0.015 ppm wet wt	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
	1	C	NG	0.011 ppm wet wt	46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
Omentum	26 of 75	ES	<2-12 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Ovary	0 of 16	ES	<2-<2 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Pancreas	2	ES	0.07-0.12 µg/g wet wt	NG	Autopsies	Schroeder, Nason, and Tipton, 1967
	13 of 139	ES	<2-<2 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Placenta	858	NAA	NG	0.023 ± 0.015 µg/g dry wt	Subjects from four large hospitals, Nashville, Tennessee	Baglan et al., 1974
	58	NG	ND	NG	Southern and southeastern city hospitals	Karp and Robertson, 1977
Prostate	1	ES	NG	0.11 µg/g wet wt	Autopsy	Schroeder, Nason, and Tipton, 1967
	3 of 50	ES	<2-<2 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Psoas	2	ES	0.05-0.22 µg/g wet wt	NG	Autopsies	Schroeder, Nason, and Tipton, 1967

Table 19. Cobalt (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Skin	2	Ch	0.016-0.023 ppm wet wt	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
	1	C	NG	0.050 ppm wet wt	46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
	5 of 22	ES	<2-11 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Spleen	1	NAA	NG	0.025 ppm wet wt	Sudden accident victims	Koch et al., 1956
	2	ES	0.06-0.30 µg/g wet wt	NG	Autopsies	Schroeder, Nason, and Tipton, 1967
	8 of 143	ES	<2-<2 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Stomach	2	ES	0.04-0.22 µg/g wet wt	NG	Autopsies	Schroeder, Nason, and Tipton, 1967
	15 of 131	ES	<2-2 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Teeth	56	MS	0.01-0.26 µg/g dry wt	0.006 µg/g dry wt	Wide geographic area	Losee, Cutress, and Brown, 1973
Testis	2	ES	0.14-0.15 µg/g wet wt	NG	Autopsies	Schroeder, Nason, and Tipton, 1967
	6 of 72	ES	<2-<2 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Thyroid	3 of 21	ES	<2-3 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Total body content	168	NG	NG	1.5 mg	Autopsy material	Schroeder, 1970*b*
Trachea	13 of 60	ES	<2-4 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Urine	2	ES	NG	0.24 ± 0.002 and 0.23 ± 0.02 mg/day	Volunteers, balance study	Tipton, Stewart, and Dickson, 1969
Uterus	3 of 32	ES	<2-<2 µg/g ash	<2 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Vena cava	1	NAA	NG	0.025 ppm wet wt	Sudden accident victims	Koch et al., 1956

Table 20. Copper

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adrenal	2	C	NG	2.6 ppm wet wt	Accident victims	Koch et al., 1956
	2	C	0.4-7.9 µg/g dry wt	4.2 mg/g dry wt	Normal subjects	Koch, Smith, and McNelly, 1957
	12	ES	160-250 µg/g ash	200 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Aorta	1	C	NG	3.5 ppm wet wt	Accident victims	Koch et al., 1956
	100	ES	1.9-12.0 micromoles/g ash	NG		Perry, 1968
	150	ES	0.79-2.20 micromoles/g ash	NG		Perry et al., 1962
	103	ES	50-140 µg/g ash	90 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Bladder	2	C	NG	1.0 ppm wet wt	Accident victims	Koch et al., 1956
	110	ES	76-180 µg/g ash	110 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Bone	40	AAS	5.0-7.3 µg/g dry wt	6.6 ± 1.74 µg/g dry wt		Janes, McCall, and Elveback, 1972
	NG	ES	NG	0.410 mg/100 g wet wt 1.190 mg/100 g wet wt	Rib bone Long bone	Kehoe, Cholak, and Story, 1940
	1	C	NG	0.4 ppm wet wt	Sudden accident victims	Koch et al., 1956
	1	C	4.5 µg/g dry wt	NG	Sudden accident victims	Koch, Smith, and McNelly, 1957
Blood	520	AAS			Serum:	Bierenbaum et al., 1975
			NG	144.60 ± 3.95 µg/100 ml	one-half sample from soft-water area, Kansas City, Missouri	
			NG	172.14 ± 4.76 µg/100 ml	one-half sample from hard-water area, Kansas City, Kansas	
	266	ES			Patients, blood donors, and normal individuals, Los Angeles area:	Butt et al., 1964
			0.071-0.110 mg/100 ml	0.0711 mg/100 ml	serum	
			0.071-0.110 mg/100 ml	0.102 mg/100 ml	whole blood	
	39	XRS	NG	1.29 ± 0.13 ppm	Healthy males, mean age 35.3 years, blood serum	Gofman et al., 1964
	NG	ES	NG	91.6 ± 2.6 µg/100 ml	Males	Hambidge and Droegemueller, 1974
				107.4 ± 5.1 µg/100 ml	Females	
	100	ASV	31-281 µg/100 ml	100 µg/100 ml		Hecker et al., 1974

Table 20. Copper (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	164	AAS	82-147 µg/100 ml	107 µg/100 ml	119 males and 45 females	Henkin, 1971
	48	AAS	950-1280 µg/liter 950-1420 µg/liter	1120 µg/liter 1170 µg/liter	Serum: male female	Hohnadel et al., 1973
	NG	ES	NG	0.114 mg/100 g		Kehoe, Cholak, and Story, 1940
	58	C	NG	98 µg/100 ml	Accident victims	Koch et al., 1956
	243	AAS	16-348 µg/ml	89 µg/ml	Males, 19 U.S. cities	Kubota, Lazar, and Lowee, 1968
	NG	NG	NG	1.2 µg/ml	Normals	Rentoul and Smith, 1973
	6	AAS	91-128 µg/ml	111 µg/ml	Males, RBC analysis	Robbins, DeKoven, and Caruso, 1975
	27 pairs	NG	12-67 µg/100 ml	36 µg/100 ml	Umbilical cord plasma	Scheinberg, Cook, and Murphy, 1954
	27 pairs	NG	118-302 µg/100 ml	216 µg/100 ml	Maternal plasma	Scheinberg, Cook, and Murphy, 1954
	60	AAS	0.22-1.70 µg/100 g	0.66 µg/100 g	White children ages 2 months to 13 years	Smith, Temple, and Reading, 1976
	558	AAS	NG	142 ± 24.82 µg/100 ml	6-year-old children, serum	Tessmer et al., 1973
	558	AAS	NG	120.40 ± 19.68 µg/100 ml	12-year-old children, serum	Tessmer et al., 1973
Brain	NG	ES	NG	0.40 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	3	C	NG	3.6 ppm wet wt	Accident victims	Koch et al., 1956
	3	C	19.3-35.1 µg/g dry wt	30.0 mg/g dry wt	Normal subjects	Koch, Smith, and McNelly, 1957
	10	ES	NG	1.23 ± 0.16 mg/100 g	0 to 3 months	Nusbaum et al., 1958
	75	ES	NG	2.07 ± 0.16 mg/100 g	Above 12 months	Nusbaum et al., 1958
	100	ES	4.7-10.0 micromoles/g ash	NG		Perry, 1968
	150	ES	3.8-8.0 micromoles/g ash	NG		Perry et al., 1962
	NG	NG	NG	23.9 µg/g dry wt	Normals	Rentoul and Smith, 1973
	127	ES	240-500 µg/g ash	360 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Diaphragm	91	ES	110-200 µg/g ash	140 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Esophagus	2	C	NG	3.5 ppm wet wt	Accident victims	Koch et al., 1956

Table 20. Copper (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	66	ES	84-200 µg/g ash	120 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Feces	2	ES	NG	1.3 ± 0.2 mg/day 1.3 ± 0.1 mg/day	Healthy 23- and 25-year-old males, University of Cincinnati	Tipton, Stewart, and Dickson, 1969
Fetal membranes	249	NG	17.5-21.5 µg/100 g	NG	Compared to specimens from lead mining region, insignificant difference	Fahim, Fahim, and Hall, 1976
Hair	33	NAA	7.8-234.0 ppm	34.1 ppm	Children and adults, Oak Ridge, Tennessee	Bate and Dyer, 1965
	50	AAS	NG		From hospital delivery ward, Cincinnati, Ohio, 68% black, 32% white:	Baumslag et al., 1974
				17.9 µg/g 13.0 µg/g 10.9 µg/g	maternal scalp hair maternal pubic hair neonatal scalp hair	
	229	AAS	1.01-144.0 µg/g	12.11 µg/g	Three New York metropolitan community samples: children	Creason et al., 1975
	204	AAS	2.22-184.0 µg/g	18.25 µg/g	Three New York metropolitan community samples: adults	Creason et al., 1975
	50	AAS	10.7-41.6 ppm 11.4-61.4 ppm	22.6 ppm 23.0 ppm	Males Females	Eads and Lambdin, 1973
	18	ES	0.00312-0.01280% dry wt	NG	White males, 15-70 years old	Goldblum, Derby, and Lerner, 1953
	165	AAS	NG	11.8, 12.6, 15.3, 22.5, and 25.7 ppm	Fourth-grade boys from five cities	Hammer, Finklea, Hendricks, Shy, and Horton, 1971
	12	AAS	9.4-31.0 µg/g	16.7 µg/g	Both sexes, varied ages, and diverse geographic areas	Hinners et al., 1974
	13	NAA	NG	13.27 µg/g		Mahler et al., 1970
	20	ES	16.0-19.5 µg/g	NG		Martin, 1964
	211	AAS	8-50 µg/g 5-60 µg/g	NG NG	Males Females	Petering, Yeager, and Witherup, 1971
	NG	NG	NG	23.1 µg/g dry wt	Normal subjects	Rentoul and Smith, 1973
	117	AAS	NG	16.1 ± 1.2 µg/g	No dyes or bleaches, males	Schroeder and Nason, 1969
	47	AAS	NG	55.6 ± 10.2 µg/g	No dyes or bleaches, females	Schroeder and Nason, 1969

Table 20. Copper (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	1	AAS	NG	70.7 ± 0.9 µg/g		Sorenson et al., 1973
	2	AAS, MS	NG	8.7 µg/g dry wt 16.2 µg/g dry wt		Yurachek, Clemena, and Harrison, 1969
Heart	NG	ES	NG	0.190 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	21	ES	NG	2.35 ± 0.27 mg/100 g	0 to 3 months	Nusbaum et al., 1958
	137	ES	NG	1.83 ± 0.09 mg/100 g	Above 12 months	Nusbaum et al., 1958
	100	ES	3.4-8.5 micromoles/g ash	NG		Perry, 1968
	150	ES	3.9-7.0 micromoles/g ash	NG		Perry et al., 1962
	NG	NG	NG	16.5 µg/g dry wt	Normal subjects	Rentoul and Smith, 1973
	140	ES	250-460 µg/g ash	350 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Intestine	NG	ES	NG	0.110 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	1 and 9	C	NG	0.4 and 4.0 ppm wet wt	Accident victims	Koch et al., 1956
	9	C	9.5-46.3 mg/g dry wt	29.7 mg/g dry wt		Koch, Smith, and McNelly, 1957
Duodenum	67	ES	160-420 µg/g ash	260 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Jejunum	101	ES	160-330 µg/g ash	230 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Ileum	84	ES	170-400 µg/g ash	240 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Cecum	31	ES	150-280 µg/g ash	220 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Sigmoid colon	108	ES	150-340 µg/g ash	210 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Rectum	42	ES	110-270 µg/g ash	170 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Kidney	NG	ES	NG	0.166 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	8	C	NG	4.1 ppm wet wt	Accident victims	Koch et al., 1956
	8	C	12.4-54.3 µg/g dry wt	30.9 µg/g dry wt	Normal subjects	Koch, Smith, and McNelly, 1957
	67	ES	NG	2.63 ± 0.34 mg/100 g	0 to 3 months	Nusbaum et al., 1958
	3	ES	NG	0.84 mg/100 g	3 to 12 months	Nusbaum et al., 1958
	201	ES	NG	1.77 ± 0.09 mg/100 g	Above 12 months	Nusbaum et al., 1958
	100	ES	3.1-16.0 micromoles/g ash	NG	Normal adults	Perry, 1968

Table 20. Copper (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	150	ES	3.0–5.4 micromoles/g ash	NG	Normal adults	Perry et al., 1962
	NG	NG	NG	14.9 µg/g dry wt	Normal subjects	Rentoul and Smith, 1973
	143	ES	190–340 µg/g ash	260 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Larynx	50	ES	14–150 µg/g ash	33 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Liver	NG	ES	NG	0.710 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	8	C	NG	9.0 ppm wet wt	Accident victims	Koch et al., 1956
	8	C	18.5–63.0 µg/g dry tissue	41.2 µg/g dry tissue	Normal subjects	Koch, Smith, and McNelly, 1957
	NG	AAS	NG	408 µg/g ash	Males	Morgan, 1972a
	46	AAS	292–420 µg/g ash	394 µg/g ash	30 white males, 16 blacks	Morgan, 1972a
	67	ES	NG	32.49 ± 1.91 mg/100 g	0 to 3 months	Nusbaum et al., 1958
	3	ES	NG	2.35 mg/100 g	3 to 12 months	Nusbaum et al., 1958
	199	ES	NG	2.76 mg/100 g dry wt	Above 12 months	Nusbaum et al., 1958
	17	AAS	3.5–8.9 µg/g wet wt	5.8 µg/g wet wt	Normal adults	Owen et al., 1977
	100	ES	7.7–32.0 micromoles/g ash	NG	Normal adults	Perry, 1968
	150	ES	5.0–21.0 micromoles/g ash	NG	Unexpected deaths	Perry et al., 1962
	10	ES	NG	1070 ± 628 µg/g ash	Males, accident victims	Perry et al., 1973
	NG	NG	NG	25.5 µg/g dry wt	Normal subjects	Rentoul and Smith, 1973
	148	ES	320–1300 µg/g ash	510 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
	7	ES or Ch	NG	5.3 ± 1.3 ppm wet wt	Noncirrhotics	Vallee et al., 1957
Lung	NG	ES	NG	0.110 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	5	C	NG	3.0 ppm wet wt	Accident victims	Koch et al., 1956
	5	C	10.5–27.8 µg/g dry wt	17.7 µg/g dry wt	Normal adults	Koch, Smith, and McNelly, 1957
	6	ES	NG	0.98 ± 0.21 mg/100 g dry wt	0 to 3 months	Nusbaum et al., 1958
	72	ES	NG	1.21 ± 0.08 mg/100 g dry wt	Above 12 months	Nusbaum et al., 1958
	100	ES	1.6–8.5 micromoles/g ash	NG	Normal adults	Perry, 1968
	150	ES	1.4–2.8 micromoles/g ash	NG	Sudden deaths	Perry et al., 1962

Table 20. Copper (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	168	NG	500–2500 µg	NG	Autopsies from cities and nonurban areas	Schroeder, 1970*b*
	141	ES	92–180 µg/g ash	120 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
	141	ES	50–250 µg/g ash	130 µg/g ash	Autopsies, nine cities	Tipton and Shafer, 1964
Milk	50	AAS	NG	0.245 ± 0.077 µg/ml	Mature human milk	Picciano and Guthrie, 1976
Muscle	NG	ES	NG	0.125 mg/100 g wet wt	Normal adults	Kehoe, Cholak, and Story, 1940
	11	C	NG	4.0 ppm wet wt	Accident victims	Koch et al., 1956
	6	C	8.0–50.3 µg/g dry wt	31.0 µg/g dry wt	Cardiac muscle	Koch, Smith, and McNelly, 1957
	5	C	4.2–17.7 µg/g dry wt	12.4 µg/g dry wt	Striated muscle	Koch, Smith, and McNelly, 1957
	136	ES	50–120 µg/g ash	74 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Nail	18	ES	0.00094–0.00810% dry tissue	NG	White males, 15–70 years old	Goldblum, Derby, and Lerner, 1953
	18	NAA	17.32–91.53 µg/g 42.59–170.00 µg/g	51.13 ± 22.84 µg/g 86.36 ± 44.51 µg/g	Adults Children	Kanabrocki et al., 1968
	13	NAA	NG	13.27 µg/g	Normal subjects	Mahler et al., 1970
	20	ES	7.7–7.8 µg/g 10.6–14.8 µg/g	NG NG	Toenails Fingernails	Martin, 1964
Omentum	75	ES	110–280 µg/g ash	190 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Ovary	16	ES	85–180 µg/g ash	120 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Pancreas	4	C	NG	2.8 ppm wet wt	Accident victims	Koch et al., 1956
	4	C	5.7–27.0 µg/g dry wt	12.2 µg/g dry wt	Normal subjects	Koch, Smith, and McNelly, 1957
	138	ES	92–210 µg/g ash	140 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Placenta	554	AAS	NG	14.40 ± 12.58 micromoles/g dry wt	One year collection from normal deliveries, Houston, Texas	Dawson et al., 1969
	554	AAS	NG	8.13 ± 0.54 to 28.54 ± 2.54 micromoles/g dry wt	Seasonal variation	Dawson et al., 1969

Table 20. Copper (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	249	NG	17.0-22.0 µg/100 g wet wt	NG	Compared to specimens from lead mining region, difference insignificant	Fahim, Fahim, and Hall, 1976
	58	NG	NG	1.598 ± 0.177 µg/g wet wt	Southern and southeastern city hospitals	Karp and Robertson, 1977
Prostate	4	C	NG	7.4 ppm wet wt	Accident victims	Koch et al., 1956
	50	ES	57-140 µg/g ash	100 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Saliva	21	NAA	2.93-15.61 µg/100 ml	7.53 ± 3.45 µg/100 ml	Normal subjects	Kanabrocki et al., 1965*b*
Skin	18	ES	0.00074-0.00880% dry wt	NG	White males, 15-70 years old	Goldblum, Derby, and Lerner, 1953
	22	ES	80-150 µg/g ash	100 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Spleen	NG	ES	NG	0.085 mg/100 g wet wt	Normal subjects	Kehoe, Cholak, and Story, 1940
	5	C	NG	2.0 ppm wet wt	Accident victims	Koch et al., 1956
	5	C	4.9-13.4 µg/g dry wt	9.2 µg/g dry wt	Normal subjects	Koch, Smith, and McNelly, 1957
	8	ES	NG	3.06 ± 1.45 mg/100 g	0 to 3 months	Nusbaum et al., 1958
	73	ES	NG	1.03 ± 0.15 mg/100 g	Above 12 months	Nusbaum et al., 1958
	100	ES	1.2-3.6 micromoles/g ash	NG	Normal adults	Perry, 1968
	150	ES	1.1-2.0 micromoles/g ash	NG	Sudden deaths	Perry et al., 1962
	143	ES	67-120 µg/g ash	89 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Stomach	NG	ES	NG	0.107 mg/100 mg wet wt	Normal subjects	Kehoe, Cholak, and Story, 1940
	4	C	NG	5.0 ppm wet wt	Accident victims	Koch et al., 1956
	4	C	13.3-25.4 µg/g dry wt	19.8 µg/g dry wt	Normal subjects	Koch, Smith, and McNelly, 1957
Sweat	48	AAS	30-1440 µg/liter 590-2280 µg/liter	550 ± 350 µg/liter 1480 ± 610 µg/liter	Male Female	Hohnadel et al., 1973
Teeth	208	MS	NG	0.51 ± 0.06 ppm	Enamel samples from subjects less than 20 years old; correlation of high caries with high level, low caries with low level	Curzon and Losee, 1977

Table 20. Copper (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	56	MS	0.07-208.0 µg/g	6.80 ± 4.01 µg/g	Subjects less than 20 years old	Losee, Cutress, and Brown, 1977
Testis	3	C	NG	2.6 ppm wet wt	Accident victims	Koch et al., 1956
	71	ES	58-110 µg/g ash	80 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Thyroid	8	C	NG	2.6 ppm wet wt	Accident victims	Koch et al., 1956
	20	ES	43-240 µg/g ash	94 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Total body content	168	NG	NG	72 mg	U.S. autopsy samples	Schroeder, 1970*b*
Trachea	60	ES	25-96 µg/g ash	56 µg/g ash (median)		Tipton and Cook, 1963
Umbilical cord	249	NG	16.5-22.0 µg/100 g	NG	Compared to specimens from lead mining region, difference insignificant	Fahim, Fahim, and Hall, 1976
Urine	NG	NAA	NG	0.028 mg/liter		Gills et al., 1974
	16	NAA, C	NG	50.37 ± 11.14 µg/day	Normal males	Kanabrocki et al., 1965*a*
	NG	ES	NG	0.034 mg/liter	Normal subjects	Kehoe, Cholak, and Story, 1940
	NG	NG	NG	0.04 µg/ml	Normal adults	Rentoul and Smith, 1973
	2	ES	NG	0.022 ± 0.003 mg/day 0.042 ± 0.013 mg/day	Healthy 23- and 25-year-old males, University of Cincinnati	Tipton, Stewart, and Dickson, 1969
Uterus	32	ES	73-130 µg/g ash	98 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Vena cava	2	C	NG	5.2 ppm wet wt	Accident victims	Koch et al., 1956

Table 21. p,p'-Dichlorodiphenyl acetic acid

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Urine	12	GC-EC	8.1-19.0 ppb	14.2 ppb	General population of Florida	Cranmer, Carroll, and Copeland, 1969
	46	IE, GC	<0.02-0.18 ppm	NG	Control population	Durham, Armstrong, and Quinby, 1965

Table 22. Dichlorodiphenyldichloroethane

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	221	GC-EC	NG	0.10 ± 0.11 ppm	Texas agricultural area	Burns, 1974
	30 of 44	CC, GC-EC	NG	0.02 ppm 0.08 ppm 0.03 ppm	Perirenal fat Mesenteric fat Panniculus fat	Casarett et al., 1968
	10	GC	0.23-14.17 ppm	3.17 ± 2.22 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
	215	GC-EC	0.21-0.34 ppm	NG	Autopsies, Dade County, Florida, diseased and normals	Deichmann and Radomski, 1968
	71	GC-EC	0.00-3.0 ppm	NG	Accidental deaths, Florida	Fiserova-Bergerova et al., 1967
	25	GC	0.09-0.99 ppm	0.45 ppm	New Orleans, Louisiana	Hayes, Dale, and Burse, 1965
	332	GC-EC	0.0-1.84 ppm	NG	Autopsies, Miami, Florida, diseased and normal	Radomski et al., 1968
	54	GC-EC	NG	0.28 ppm	Autopsy tissues	Radomski and Deichmann, 1968
	202	GC-EC	0.0-1.2 ppb	0.10 ppb	Surgical biopsies in Idaho	Wyllie, Gabica, and Benson, 1972
Adrenal	18 of 44	CC, GC-EC	NG	0.94 ppm of extracted lipid	General population of Hawaii, autopsies ages 28 weeks-88 years	Casarett et al., 1968
	10	GC	0.91-1.45 ppm	1.11 ± 0.17 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
Blood	30	GC	0.0013-0.0015 ppm	0.0014 ± 0.0001 ppm	Cord blood	Curley, Copeland, and Kimbrough, 1969
	7	GC-EC	0.0001-0.0027 ppm	NG	Pregnant women, plasma	Curley and Kimbrough, 1969
	20	GC	0.0029-0.0199 ppm 0.0015-0.0066 ppm 0.0018-0.0425 ppm 0.0078-0.0319 ppm 0.0057-0.0448 ppm 0.032-0.0150 ppm	0.0083 ppm 0.0037 ppm 0.0121 ppm 0.0139 ppm 0.0189 ppm 0.0079 ppm	Plasma, males Plasma, females Red blood cells, males Red blood cells, females Whole blood, males Whole blood, females	Dale, Curley, and Hayes, 1967
	350 pairs	GC	2.0-5.5 ppb	NG	Mother-infant pairs in Mississippi	D'Ercole et al., 1976
	723	GC-EC	0-5 ppb	0.28 ppb	General population	Finklea et al., 1972

Table 22. Dichlorodiphenyldichloroethane (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	53 pairs	GC-EC	0.5-2.4 ppb	1.58 (geometric mean)	Louisiana housewives, general population, maternal blood	Selby et al., 1969
	1000	GC-EC	0.0-27.0 ppb	0.24 ppb	General population of Idaho, serum	Watson, Benson, and Gabica, 1970
	202	GC-EC	0.0-4.0 ppb	0.10 ppb	Surgical biopsies in Idaho, serum	Wyllie, Gabica, and Benson, 1972
Bone	30 of 44	CC, GC-EC	NG	1.45 ppm of extracted lipid	General population of Hawaii, autopsies, ages 28 weeks to 88 years, bone marrow	Casarett et al., 1968
Brain	32 of 44	CC, GC-EC	NG	0.22 ppm of extracted lipid	General population of Hawaii, autopsies, ages 28 weeks to 88 years	Casarett et al., 1968
	10	GC	0.20-1.22 ppm	0.64 ± 0.30 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
Gonad	36 of 44	CC, GC-EC	NG	0.18 ppm of extracted lipid	General population of Hawaii, autopsies, ages 28 weeks to 88 years	Casarett et al., 1968
Heart	10	GC	1.02-5.82 ppm	3.27 ± 1.10 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
Human tissue	115	GC-EC	1.0-76 ppb	NG	General population of Hawaii	Klemmer et al., 1977
Kidney	38 of 44	CC, GC-EC	NG	0.12 ppm of extracted lipid	General population of Hawaii, autopsies, ages 28 weeks to 88 years	Casarett et al., 1968
	10	GC	0.48-9.12 ppm	3.84 ± 1.87 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
	71	GC-EC	0.00-0.23 ppm	NG	Accidental deaths, Florida	Fiserova-Bergerova et al., 1967
	54	GC-EC	NG	0.017 ppm	General population	Radomski and Deichmann, 1968
Liver	42 of 44	CC, GC-EC	NG	2.43 ppm of extracted lipid	General population of Hawaii, autopsies, ages 28 weeks to 88 years	Casarett et al., 1968
	10	GC	0.19-2.14 ppm	1.01 ± 0.29 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969

Table 22. Dichlorodiphenyldichloroethane (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	71	GC-EC	0.00-1.60 ppm	NG	Accidental deaths, Florida	Fiserova-Bergerova et al., 1967
	54	GC-EC	NG	0.34 ppm	Autopsies, general population	Radomski and Deichmann, 1968
Lung	25 of 44	CC, GC-EC	NG	0.05 ppm of extracted lipid	General population of Hawaii, autopsies, ages 28 weeks to 88 years	Casarett et al., 1968
	10	GC	0.31-1.05 ppm	0.75 ± 0.13 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
Lymph nodes	11 of 44	CC, GC-EC	NG	0.03 ppm of extracted lipid	General population of Hawaii, autopsies, ages 28 weeks to 88 years	Casarett et al., 1968
Milk	10	GC-EC	<0.0001-0.0140 ppm	NG	Lactating women	Curley and Kimbrough, 1969
	53	GC	0.04-0.30 mg/kg, fat	0.17 mg/kg, fat	Nursing mothers in Pennsylvania	Kroger, 1972
	40	GC	Trace to 5.0 ppb, fat	0.70 mg/kg, fat	Females, rural Colorado	Savage et al., 1973
Placenta	53 pairs	GC-EC	0.1-17.2 ppb	0.62 (geometric mean)	Louisiana housewives, general population	Selby, Newell, Hauser, and Junker, 1969
Spleen	27 of 44	CC, GC-EC	NG	0.49 ppm of extracted lipid	General population of Hawaii, autopsies, ages 28 weeks to 88 years	Casarett et al., 1968
	10	GC	0.18-0.91 ppm	0.56 ± 0.21 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
Urine	12	GC-EC	0.25-0.43 ppb	0.34 ppb	General population of Florida	Cranmer, Carroll, and Copeland, 1969

Table 23. *o,p'*-Dichlorodiphenyldichloroethylene

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	25	GC	0.05–0.53 ppm	0.29 ppm	New Orleans, 1964	Hayes, Dale, and Burse, 1965
Blood	10	GC	<0.0003–0.0085 ppm	0.0022 ppm	Men, general population, whole blood	Dale, Curley, and Hayes, 1967
	10	GC	<0.0003–0.0025 ppm	0.0010 ppm	Women, general population, whole blood	Dale, Curley, and Hayes, 1967
	10	GC	<0.0006–0.0096 ppm	0.0036 ppm	Men, general population, plasma	Dale, Curley, and Hayes, 1967
	10	GC	<0.0006–0.0023 ppm	0.0012 ppm	Women, general population, plasma	Dale, Curley, and Hayes, 1967
	10	GC	<0.0007–0.0031 ppm	0.0012 ppm	Men, general population, red blood cells	Dale, Curley, and Hayes, 1967
	10	GC	<0.0003–0.0039 ppm	0.0016 ppm	Women, general population, red blood cells	Dale, Curley, and Hayes, 1967
Milk	7	GC-EC	<0.0001–0.0028 ppm	NG	Lactating women	Curley and Kimbrough, 1969
Pancreas	10	GC	NG	0.08 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
Spleen	10	GC	NG	0.29 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
Urine	6	GC-EC	<0.0001–0.0010 ppm	NG	General population	Cueto and Biros, 1967

Table 24. *p,p'*-Dichlorodiphenyldichloroethylene

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	NG	GC/MS	NG	28.71 ppm	Combined GC/MS	Biros and Walker, 1970
	221	GC-EC	NG	17.37 ± 10.90 ppm	Agricultural area, Texas, tissues from surgery, 1969-1972	Burns, 1974
	29	GC-EC	NG	4.40 ppm, whole tissue 10.26 ppm, fat	Autopsies, Hawaii, 28 weeks to 88 years, mesenteric	Casarett et al., 1968
	30	GC-EC	NG	4.48 ppm, whole tissue 9.86 ppm, fat	Autopsies, Hawaii, 28 weeks to 88 years, panniculus	Casarett et al., 1968
	30	GC-EC	NG	4.64 ppm, whole tissue 11.47 ppm, fat	Autopsies, Hawaii, 28 weeks to 88 years, perirenal	Casarett et al., 1968
	10	GC	0.16-3.19 ppm	1.22 ± 0.38 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
	30	GC	0.48-10.40 ppm	3.82 ppm	Three widespread geographic areas	Dale and Quinby, 1963
	11	GC-EC	1.9-13.2 ppm	6.92 ppm	Autopsies, Florida	Davies, Welke, and Radomski, 1965
	159	GC-EC	0.44-23.4 ppm	NG	Autopsies, Florida, general population	Davies et al., 1968
	90	GC-EC	NG	5.5 ppm	Autopsies, whites	Davies et al., 1969
	35	GC-EC	NG	10.8 ppm	Autopsies, blacks	
	90	GC-EC	0.9-13.80 ppm	5.5 ppm	Controls for anticonvulsant therapy study	Davies et al., 1969
	11	GC-EC	3.5-20.8 ppm	10.5 ppm	Controls for experiment on reduction of pesticide residues with diphenylhydantoin	Davies et al., 1971
	42	GC-EC	NG	6.69-17.91 ppm	Autopsies, controls	Deichmann and MacDonald, 1968
	173	GC-EC	NG	7.33-17.91 ppm	Range of means, various diseases, hypertension high	
	143 males	GC	NG	7.4 ± 2.8 ppm	Female smokers, black	Domanski et al., 1977
				3.4 ± 1.0 ppm	Female smokers, white	
				8.4 ± 2.9 ppm	Female nonsmokers, black	
				3.5 ± 1.0 ppm	Female nonsmokers, white	
				9.3 ± 1.4 ppm	Male smokers, black	
				5.9 ± 1.4 ppm	Male smokers, white	
				11.6 ± 2.8 ppm	Male nonsmokers, black	
				4.3 ± 1.5 ppm	Male nonsmokers, white	
					Smoking may induce enzymes which metabolize dichlorodiphenyltrichloroethane	

Table 24. p,p'-Dichlorodiphenyldichloroethylene (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	71	GC-EC	0.87-27.20 ppm	NG	Accidental deaths	Fiserova-Bergerova et al., 1967
	61	C	2-13 ppm	6.1 ppm	U.S. general population, 1954	Hayes, Durham, and Cueto, 1956
	25	GC	0.56-21.17 ppm	6.85 ppm	People in New Orleans	Hayes, Dale, and Burse, 1965
	43	C	2.6-21.7 ppm	12.5 ppm	Prison inmates before experimental oral doses of dichlorodiphenyltrichloroethane, 1956	Hayes, Dale, and Pirkle, 1971
	282	GC	NG	7.4 ± 5.3 ppm	Study of progression of storage of dichlorodiphenyltrichloroethane metabolites in general population, 1963	Hoffman, Harrison, and Schaefer, 1964
	994	GC	0-56.1 ppm	7.0 ppm	Autopsies, no outstanding differences between normals and persons dying of a variety of diseases	Hoffman et al., 1967
	3	C	0.1-0.4 ppm	NG	Autopsy tissues, 1938-1940	Mattson et al., 1953
	50	C	ND-49 ppm	NG	Autopsy tissues, 1952	
	70	GC-EC	NG	4.58 ppm	Autopsies, Arizona, 1966-1968	Morgan and Roan, 1970
	130	C	1.7-30.8 ppm	7.8 ppm	93% biopsy, 7% autopsy, U.S. general population, 1961-1962	Quinby et al., 1965
	332	GC-EC	3.66 ± 7.64 to 19.27 ± 6.35 ppm (normals 6.69 ± 4.07)		Autopsies, Florida, 1964-1967, range of means in various diseases, metastatic malignancy highest	Radomski et al., 1968
	54	GC-EC	NG	6.67 ppm	General population	Radomski and Deichmann, 1968
	64	GC-EC	1.8-13.5 µg/g, fat	5.1 µg/g, fat	Autopsy tissues	Rappolt and Hale, 1968
	62	GC-EC, TLC	0.195-27.302 ppm	3.70 ppm (geometric mean)	Environmental vs chemical	Selby, Nevell, Waggenspack, Hauser, and Junker, 1969
	103	GC	NG	5.0 ppm	Utah, 1967-1970	Warnick, 1972
	202	GC-EC	0.2-30 ppb	7.2 ppb	141 females, 61 males, surgical tissues, Idaho, 1970	Wyllie, Gabica, and Benson, 1972

Table 24. *p,p'*-Dichlorodiphenyldichloroethylene (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adrenal	18	GC-EC	NG	0.87 ppm, whole tissue	Autopsies, Hawaii, 28 weeks to 88 years	Casarett et al., 1968
	18		NG	8.57 ppm, fat		
	10	GC	0.13-1.96 ppm	1.05 ± 0.28 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
Amniotic fluid	70	GC	0-12 ppb	2.4 ppb	Whites	O'Leary, Davies, Edmundson, and Reich, 1970
	70	GC	1-20 ppb	2.6 ppb	Blacks	
Bile	5	GC-EC	0.5-5.1 ppb	2.3 ppb	Elderly men, evidence of excretion of pesticide metabolites by liver	Paschal, Roan, and Morgan, 1974
Blood	960	GC-EC	6.75-34.83 ppb	20.56 ppb	Michigan counties, 1968-1970	Bloomer et al., 1977
	3041	NG	NG	25.0 ± 22.0 ppb	Effect of pesticides on blood pressure	Budy, Rashad, and Mi, 1977
	40	GC	0.0011-0.0160 ppm	0.0062 ± 0.0005 ppm	Cord blood	Curley, Copeland, and Kimbrough, 1969
	7	GC-EC	0.0004-0.0132 ppm	NG	Pregnant women	Curley and Kimbrough, 1969
	10	GC-EC	NG	0.0152 ppm	Women with no occupational exposure to insecticides, serum	Dale, Curley, and Cueto, 1966
	10	GC-EC	0.0045-0.0235 ppm	0.0114 ppm	Blood	Dale, Curley, and Cueto, 1966
	10	GC-EC	0.0069-0.0499 ppm	0.0257 ppm	Plasma	
	10	GC-EC	0.0055-0.0475 ppm	0.0198 ppm	Serum	
					Extension of above study	
	10	GC-EC	0.0062-0.0367 ppm	0.0178 ppm	Males, general population	Dale, Curley, and Hayes, 1967
	10	GC-EC	0.0068-0.0107 ppm	0.0088 ppm	Females, general population	
	10	GC-EC	0.0101-0.0416 ppm	0.0257 ppm	Males, general population, plasma	
	10	GC-EC	0.0039-0.0344 ppm	0.0135 ppm	Females, general population, plasma	
	119	GC-EC	2-54 ppb	NG	General population, Florida	Davies et al., 1968
	68	GC-EC	NG	8 ppm	General population, Florida, 1967-1968, whites	Davies et al., 1969
	51	GC-EC	NG	16 ppm	General population, Florida, 1967-1968, blacks	Davies et al., 1969
	800	GC-EC	1-78 ppb	24.3 ppb	Whites, higher social class	Davies et al., 1973
			18-67 ppb	31.2 ppb	Blacks, higher social class	
			3-163 ppb	35.3 ppb	Whites, lower social class	
			4-180 ppb	46.8 ppb	Blacks, lower social class	

Table 24. *p,p'*-Dichlorodiphenyldichloroethylene (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	199	GC-EC	1-55 ppb	9.1 ppb	Controls for anticonvulsant therapy study	Davies et al., 1971
	209 pairs	GC	NG	90 ppb 30 ppb	Agricultural area, 1972, Mississippi, serum: mothers, black newborn, black	D'Ercole et al., 1976
	130 pairs	GC	NG	35 ppb 20 ppb	mothers, white newborn, white	
	28	GC	6.1-114.0 ppb	39.5 ppb	Rural and urban areas, Texas, relation to dichlorodiphenyldichloroethylene in milk, serum	Dyment et al., 1971
	723	GC-EC	0.1-43.5 ppb	5.68 ppb	Blacks and whites, urban and rural, plasma	Finklea et al., 1972
	9	GC-EC	10-41 ppb	21 ppb	Study of release of dichlorodiphenyldichloroethylene by tissue wasting and stress, patients	Hesselberg and Scherr, 1974
	14	GC-EC	2-7 ppb	3 ppb	Study of release of dichlorodiphenyldichloroethylene by tissue wasting and stress, nonpatients	Hesselberg, and Scherr, 1974
	96	GC-EC	NG	24.6 ± 14.2 ppb	White children, ages 6-9 years, 1970, South Carolina, plasma	Keil et al., 1972
	96	GC-EC	NG	55.2 ± 29.5 ppb	Black children, ages 6-9 years, South Carolina, plasma	Keil et al., 1972
	1619	GC	1-130 ppb	16.4 ppb	1130 subjects from urban Honolulu, 489 from rural Lanai, 1968-1970, serum	Klemmer, Rashad, and Mi, 1973
	70	GC	3-29 ppb 3-92 ppb 1-13 ppb 2-12 ppb	10.8 ppb 15.2 ppb 4.8 ppb 5.9 ppb	Maternal blood, whites Maternal blood, blacks Cord blood, whites Cord blood, blacks	O'Leary, Davies, Edmundson, and Feldman, 1970
	23	GC	6.6-34.4 ppb	19.5 ppb	Premature infants, Florida	O'Leary, Davies, Edmundson, and Feldman, 1970
	44	GC	2-13 ppb	5.8 ppb	Term infants, Florida	
	8	GC-EC	NG	15.72 ± 6.51 ppb	Florida	Radomski et al., 1971
	10	GC-EC	0.0-25.9 µg/g, fat	5.1 µg/g, fat	Newborns, fetal cord	Rappolt and Hale, 1968

Table 24. *p,p'*-Dichlorodiphenyldichloroethylene (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	3568	NG	NG	25.4 ± 26.7 ppb	Hawaii, community at large, 1969-1970. Presence of *p,p'*-dichlorodiphenyldichloroethylene may stimulate synthesis or release of cholesterol in liver, leading to an elevated serum cholesterol. Serum	Rashad et al., 1976
	62	GC-EC, TLC	0.3-22.4 ppb	2.56 ppb	Environmental vs chemical	Selby, Newell, Hauser, and Junker, 1969
	53 pairs	GC-EC	0.3-32.4 ppb	2.65 ppb (geometric mean)	53 mothers, Louisiana: 36 rural, 16 urban, 1966-1967	Selby, Newell, Hauser, and Junker, 1969
	40	GC-EC	0.005-0.022 ppm	0.011 ppm	Eskimo children, ages 6-17 years, 20 males, 20 females, 1972, maternal blood	Serat et al., 1977
	1417	GC	NG	19.8 ppb	Utah, 1967-1970, serum	Warnick, 1972
	1000	GC-EC	0-383 ppb 1-121 ppb	22.0 ppb 18.8 ppb	Idaho, 1967-1968, ages 3-90 years, goes up with age, serum: males females	Watson, Benson, and Gabica, 1970
	24	GC-EC	26-78 ppb	45.5 ppb	Male agricultural workers, Idaho, 1970, serum	Watson et al., 1973
	24	GC-EC	23-98 ppb	57.5 ppb	Male agricultural workers, Idaho, 1970, serum	Watson et al., 1973
	202	GC-EC	2-70 ppb	15.5 ppb	141 females, 61 males, surgical patients, Idaho, 1970, serum	Wyllie, Gabica, and Benson, 1972
Brain	32	GC-EC			Autopsies, Hawaii, 28 weeks to 88 years:	Casarett et al., 1968
			NG NG	0.0831 ppm 1.59 ppm	whole tissue fat	
	10	GC	0.25-1.47 ppm	0.65 ± 0.28 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
	11	GC-EC	0.13-0.57 ppm	0.30 ppm	Autopsies, Florida	Davies, Welke, and Radomski, 1965
	71	GC-EC	0.00-0.57 ppm	NG	Accidental deaths	Fiserova-Bergerova et al., 1967
	70	GC-EC	NG	0.084 ppm	Autopsies, Arizona, 1966-1968	Morgan and Roan, 1970

Table 24. *p,p'*-Dichlorodiphenyldichloroethylene (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	332	GC-EC	Trace to 0.20 ± 0.18 ppm (normals 0.12 ± 0.19)		Autopsies, Florida, 1964-1967, range of means in various diseases, no disease outstanding	Radomski et al., 1968
	54	GC-EC	NG	0.123 ppm	General population	Radomski and Deichmann, 1968
Gonad	36	GC-EC	NG	0.068 ppm, whole tissue	Autopsies, Hawaii, 28 weeks to 88 years	Casarett et al., 1968
	36			7.78 ppm, fat		
	11	GC-EC	0.03-0.66 ppm	0.27 ppm	Autopsies, Florida	Davies, Welke, and Radomski, 1965
	71	GC-EC	0.00-0.31 ppm	NG	Accidental deaths	Fiserova-Bergerova et al., 1967
	54	GC-EC	NG	0.059 ppm	General population	Radomski and Deichmann, 1968
Heart	10	GC	1.27-4.79 ppm	2.74 ± 0.74 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
Kidney	38	GC-EC	NG	0.209 ppm, whole tissue	Autopsies, Hawaii, 28 weeks to 88 years	Casarett et al., 1968
	38			6.32 ppm, fat		
	10	GC	0.11-9.78 ppm	3.57 ± 1.72 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
	11	GC-EC	0.08-1.2 ppm	0.35 ppm	Autopsies, Florida	Davies, Welke, and Radomski, 1965
	71	GC-EC	0.00-0.57 ppm	NG	Accidental deaths	Fiserova-Bergerova et al., 1967
	70	GC-EC	NG	0.133 ppm	Autopsies, Arizona, 1966-1968	Morgan and Roan, 1970
	54	GC-EC	NG	0.077 ppm	General population	Radomski and Deichmann, 1968
Liver	NG	GC/MS	NG	3.56 ppm	Emphasis on methodology	Biros and Walker, 1970
	42	GC-EC	NG	0.200 ppm, whole tissue	Autopsies, Hawaii, 28 weeks to 88 years	Casarett et al., 1968
	42			12.93 ppm, fat		
	10	GC	0.22-2.45 ppm	0.98 ± 0.34 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
	11	GC-EC	0.11-4.8 ppm	1.01 ppm	Autopsies, Florida	Davies, Welke, and Radomski, 1965
	71	GC-EC	Trace to 2.00 ppm	NG	Accidental deaths	Fiserova-Bergerova et al., 1967

Table 24. p,p'-Dichlorodiphenyldichloroethylene (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	70	GC-EC	NG	0.432 ppm	Autopsies, Arizona, 1966-1968	Morgan and Roan, 1970
	332	GC-EC	0.29 to 2.44 ± 9.16 ppm (normals 0.35 ± 0.01)		Autopsies, Florida, 1964-1967, range of means in various diseases, metastatic malignancy highest	Radomski et al., 1968
	54	GC-EC	NG	0.35 ppm	General population	Radomski and Deichmann, 1968
Lung	25	GC-EC	NG	0.0585 ppm, whole tissue 8.78 ppm, fat	Autopsies, Hawaii, 28 weeks to 88 years	Casarett et al., 1968
	10	GC	0.25-1.35 ppm	0.85 ± 0.22 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
Lymph nodes, tracheobronchial	11 11	GC-EC	NG	1.38 ppm, whole tissue 8.31 ppm, fat	Autopsies, Hawaii, 28 weeks to 88 years	Casarett et al., 1968
Marrow, bone	19 30	GC-EC	NG	2.08 ppm, whole tissue 18.47 ppm, fat	Autopsies, Hawaii, 28 weeks	Casarett et al., 1968
Milk	10	GC-EC	0.0052-0.0981 ppm	NG	Lactating women	Curley and Kimbrough, 1969
	28	GC	13.4-236.0 ppb	84.1 ppb	Mothers in rural and urban areas in Texas, milk higher than blood, hazard for infant	Dyment et al., 1971
	6	GC-EC	0.074-0.214 ppm	NG	Mothers in Arizona, 1972	Hagyard et al., 1973
	53	GC	0.63-4.05 mg/kg, fat	2.32 mg/kg, fat	Nursing mothers, Philadelphia area, 1970	Kroger, 1972
	10	C	<0.3-4.5 ppm, fat basis	1.4 ppm, fat basis	Normal mothers, four cities, 1960-1961	Quinby, Armstrong, and Durham, 1965
	40	GC	19-386 ppb, fat basis	111.6 ppb, fat basis	Normal mothers, rural Colorado, 1971-1972	Savage et al., 1973
	1434	GC-EC	125-214,166 ppb, fat basis	3520.9 ppb, fat basis	Five areas, national study, 1975-1976	Savage, 1976
	57	GC-EC, GC/MS	0.01-1.72 ppm	0.227 ppm	Mothers from selected areas of Arkansas and Mississippi, 1973-1974, 27% blacks, whole-milk basis	Strassman and Kutz, 1977

Table 24. *p,p'*-Dichlorodiphenyldichloroethylene (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Pancreas	10	GC	NG	0.23 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
Placenta	39	GC-EC	1.8-13.5 µg/g fat	5.0 µg/g fat		Rappolt and Hale, 1968
	53	GC-EC	0.6-65.8 ppb	10.42 ppb (geometric mean)	Newborns from 52 mothers, Louisiana, 1966-1967, 36 rural, 16 urban	Selby, Nevell, Hauser, and Junker, 1969
Red blood cells	10	GC-EC	0.0008-0.0049 ppm	0.0026 ppm	Emphasis on methodology	Dale, Curley, and Cueto, 1966
	20	GC-EC	0.0046-0.0138 ppm 0.0061-0.0151 ppm	0.0090 ppm 0.0091 ppm	General population, 10 males General population, 10 females	Dale, Curley, and Hayes, 1967
Spinal cord	10	GC	0.30-1.16 ppm	0.73 ± 0.43 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
Spleen	27 27	GC-EC	NG	0.0305 ppm, whole tissue 6.05 ppm, fat	Autopsies, Hawaii, 28 weeks to 88 years	Casarett et al., 1968
	10	GC	0.60-1.05 ppm	0.86 ± 0.13 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
Urine	12	GC-EC	0.41-0.55 ppb	0.42 ppb	General population of Florida	Crammer, Carroll, and Copeland, 1969
	10	GC-EC	0.0114-0.0285 ppm	NG	General population	Cueto and Biros, 1967

Table 25. Dichlorodiphenyltrichloroethane

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	NG	NG	NG	0.8-7.4 ppm	United States, 1955-1967	Bevenue, 1976
	11	GC-EC	0.9-4.2 ppm	2.1 ppm	Control group	Davies et al., 1971
	215	GC-EC	2.11-6.54 ppm	NG	Autopsies, Florida	Deichmann and Radomski, 1968
	61	C	2-12 ppm	4.9 ppm	1954-1956, general population	Hayes, Durham, and Cueto, 1956
	43	C	2.0-12.5 ppm	5.0 ppm	Prison inmates, 24-29 years old, 1956	Hayes, Dale, and Pirkle, 1971
	282	GC	0-20 ppm	2.9 ppm	Autopsies, Chicago, 1963	Hoffman, Harrison, and Schaefer, 1964
	994	GC	0-19.0 ppm	2.6 ppm	Autopsies, 1962-1967	Hoffman et al., 1967
	1	Ch	NA	17 ppm	1948, male subject, 37 years old, had worked experimentally with dichlorodiphenyltrichloroethane and consumed it in food, especially milk	Howell, 1948
	35	C	0-34.0 ppm	5.1 ppm	Appears to be first report of dichlorodiphenyltrichloroethane in human milk and fat from nonoccupational exposure	Laug, Prickett, and Kunze, 1950
	75	C	<0.1-34 ppm	5.3 ppm	Follow-up of Laug et al., 1950	Laug, Kunze, and Prickett, 1951
	50	C	0-40 ppm	NG	Samples taken in 1952	Mattson et al., 1953
	3	C	0.3-0.6 ppm	NG	Samples taken in 1938-1940	Mattson et al., 1953
	70	GC-EC	NG	1.54 ppm	Autopsies, Arizona, 1966-1968	Morgan and Roan, 1970
	130	C	0.7-25.4 ppm	4.0 ppm	93% biopsy, 7% autopsy, four U.S. cities, 1961-1962	Quinby et al., 1965
	19	GC-EC	2.2-31.0 ppm	8.8 ppm	Autopsies from accidental deaths, 18-76 years old, Ohio, 1964-1965	Schafer and Campbell, 1966
	103	GC	NG	1.5 ppm	Utah, 1967-1970	Warnick, 1972
Adrenal	18	GC-EC	NG	0.98 ppm, fat 0.125 ppm, whole tissue	Autopsies, Hawaii, 28 weeks to 88 years	Casarett et al., 1968
Amniotic fluid	152	GC	NG	6 ppb 14 ppb	Whites Blacks	O'Leary, Davies, and Feldman, 1970

Table 25. Dichlorodiphenyltrichloroethane (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	960	GC	NG	5.76 ppb	Michigan general population, 1968-1970	Bloomer et al., 1977
	96	GC-EC	NG		Children, ages 6-9, South Carolina:	Keil et al., 1972
				6.6 ± 6.5 ppb	whites	
				18.5 ± 11.0 ppb	nonwhites	
	192	GC-EC	NG		Children, ages 6-9, South Carolina, 1970, plasma:	Keil et al., 1972
				7.8-8.9 ppb	white males	
				4.7-4.8 ppb	white females	
				16.5-17.7 ppb	nonwhite males	
				19.9-20.5 ppb	nonwhite females	
	152	NG			Normal pregnancies, Florida:	O'Leary, Davies, and Feldman, 1970
			3-29 ppb	11 ppb	whites	
			3-92 ppb	15 ppb	blacks	
	101	NG			Spontaneous abortions, Florida:	O'Leary, Davies, and Feldman, 1970
			3-28 ppb	9 ppb	whites	
			2-47 ppb	12 ppb	blacks	
	19	GC-EC	2-94 ppb	20.3 ppb	Autopsies from accidental deaths, 18-76 years old, Ohio, 1964-1965	Schafer and Campbell, 1966
	53	GC-EC	0.2-32.3 ppb	1.82 ppb (geometric mean)	Maternal blood, 51 white and 2 black housewives, Louisiana, 36 rural, 16 urban	Selby, Newell, Hauser, and Junker, 1969
	29	GC-EC	<0.002 ppm	NG	Eskimo children, Alaska, 6-17 years old, 20 males and 20 females, serum	Serat et al., 1977
	9		0.002-0.003 ppm			
	1417	GC	NG	6.2 ppb	Utah, 1967-1970	Warnick, 1972
Brain	32	GC-EC	NG	0.12 ppm, fat	Autopsies, Hawaii, 28 weeks to 88 years	Casarett et al., 1968
				0.0105 ppm, whole tissue		
	11	GC-EC	0.08-0.44 ppm	0.24 ppm	Autopsies, Florida	Davies, Welke, and Radomski, 1965
	70	GC-EC	NG	0.022 ppm	Autopsies, Arizona, 1966-1968	Morgan and Roan, 1970
Endometrium	15	GC-EC	NG	Trace	Hawaii, maternal	Klemmer et al., 1977
Fat	30	GC-EC	NG	3.14 ppm, fat	Autopsies, Hawaii, 28 weeks to 88 years, perirenal	Casarett et al., 1968
				1.33 ppm, whole tissue		

Table 25. Dichlorodiphenyltrichloroethane (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	29	GC-EC	NG	2.85 ppm, fat 1.35 ppm, whole tissue	Autopsies, Hawaii, 28 weeks to 88 years, mesenteric	Casarett et al., 1968
	30	GC-EC	NG	2.81 ppm, fat 1.16 ppm, whole tissue	Autopsies, Hawaii, 28 weeks to 88 years, panniculus	Casarett et al., 1968
	30	GC-EC	0.92-6.6 ppm	3.79 ppm	Autopsies, Florida	Davies, Welke, and Radomski, 1965
Fetal	15	GC-EC	0-4.9 ppb	0.4 ppb	Hawaii	Klemmer et al., 1977
Gonad	36	GC-EC	NG	1.53 ppm, fat 0.0150 ppm, whole tissue	Autopsies, Hawaii, 28 weeks to 88 years	Casarett et al., 1968
	11	GC-EC	0.04-0.40 ppm	0.21 ppm	Autopsies, Florida	Davies, Welke, and Radomski, 1965
Kidney	38	GC-EC	NG	1.66 ppm, fat 0.0827 ppm, whole tissue	Autospies, Hawaii, 28 weeks to 88 years	Casarett et al., 1968
	11	GC-EC	0.07-0.42 ppm	0.21 ppm	Autopsies, Florida	Davies, Welke, and Radomski, 1965
	70	GC-EC	NG	0.030 ppm	Autopsies, Arizona, 1966-1968	Morgan and Roan, 1970
Liver	42	GC-EC	NG	1.75 ppm, fat 0.0467 ppm, whole tissue	Autopsies, Hawaii, 28 weeks to 88 years	Casarett et al., 1968
	11	GC-EC	0.17-1.2 ppm	0.38 ppm	Autopsies, Florida	Davies, Welke, and Radomski, 1965
	70	GC-EC	NG	0.101 ppm	Autopsies, Arizona, 1966-1968	Morgan and Roan, 1970
Lung	27 25	GC-EC	NG	2.62 ppm, fat 0.0147 ppm, whole tissue	Autopsies, Hawaii, 28 weeks to 88 years	Casarett et al., 1968
Lymph nodes	11	GC-EC	NG	3.73 ppm, fat 0.892 ppm, whole tissue	Autopsies, Hawaii, 28 weeks to 88 years, tracheobronchial	Casarett et al., 1968
Marrow	30 19	GC-EC	NG	4.48 ppm, fat 0.411 ppm, whole tissue	Autopsies, Hawaii, 28 weeks to 88 years	Casarett et al., 1968
Milk	6	GC-EC	0-200 ppb	30 ppb	Hawaii	Klemmer et al., 1977
	24	C	0.04-0.77 ppm	0.14 ppm	Appears to be first report of dichlorodiphenyltrichloroethane in human milk and fat from nonoccupational exposure	Laug, Prickett, and Kunze, 1950

Table 25. Dichlorodiphenyltrichloroethane (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	24	C	<0.01-0.77 ppm	0.13 ppm	Follow-up of Laug et al., 1950	Laug, Kunze, and Prickett, 1951
	14	C	<0.3-7.7 ppm, fat	2.5 ppm	Normal mothers, four U.S. cities	Quinby, Armstrong, and Durham, 1965
Placenta	53	GC-EC	1.1-152.0 ppb	13.82 ppb	Childbirth — 51 white and 2 black mothers, Louisiana housewives, 36 rural, 16 urban, 1966-1967	Selby, Newell, Hauser, and Junker, 1969
Spleen	27	GC-EC	NG	2.62 ppm, fat 0.0112 ppm, whole tissue	Autopsies, Hawaii, 28 weeks to 88 years	Casarett et al., 1968
Total body content	77	GC-EC	11-1350 ppb	NG	Autopsies, Hawaii, 1964-1973	Klemmer et al., 1977
	19	GC-EC	22-300 mg, total body burden	NG	Autopsies from accidental deaths, 18-76 years old, Ohio, 1964-1965	Schafer and Campbell, 1966

Table 26. *o,p'*-Dichlorodiphenyltrichloroethane

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	NG	GC/MS	NG	0.63 ppm	Emphasis on methodology	Biros and Walker, 1970
	221	GC-EC	NG	0.24 ± 0.28 ppm	Texas agricultural area	Burns, 1974
	10	GC	0.35-11.47 ppm	3.39 ± 2.70 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
	30	GC	<0.09-8.24 ppm	1.30 ppm	From three widespread areas	Dale and Quinby, 1963
	25	GC	<0.01-0.67 ppm	0.06 ppm	General population in Louisiana	Hayes, Dale, and Burse, 1965
	54	GC-EC	0.05-1.4 ppm	NG	General population of Florida	Radomski and Deichmann, 1962
	202	GC-EC	0.0-1.0 ppm	0.10 ppm	Surgical biopsies in Idaho	Wyllie, Gabica, and Benson, 1972
Adrenals	10	GC	0.36-1.05 ppm	0.71 ± 0.35 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
Bile	5	GC-EC	0.0-0.2 ppb	0.06 ppb	Elderly men, bile duct drainage, evidence of excretion by liver	Paschal, Roan, and Morgan, 1974
Blood	30	GC	0.0004-0.0044 ppm	0.0011 ± 0.0002 ppm	Cord blood	Curley, Copeland, and Kimbrough, 1969
	7	GC-EC	<0.0001-0.0126 ppm	NG	Pregnant women	Curley and Kimbrough, 1969
	20	GC	0.0014-0.0129 ppm	0.0060 ppm	Plasma, males	Dale, Curley, and Hayes, 1967
			0.0014-0.0039 ppm	0.0024 ppm	Plasma, females	
			0.0025-0.0054 ppm	0.0044 ppm	Red blood cells, males	
			<0.0003-0.0037 ppm	0.0022 ppm	Red blood cells, females	
			0.0014-0.0336 ppm	0.0082 ppm	Whole blood, males	
			0.0016-0.0065 ppm	0.0033 ppm	Whole blood, females	
	10	GC-EC	NG	0.0016 ppm	Females, no occupational exposure	Dale, Curley, and Cueto, 1966
	10	GC-EC	<0.0001-0.0036 ppm	0.0013 ppm	Plasma	Dale, Curley, and Cueto, 1966
			0.0005-0.0017 ppm	0.0010 ppm	Whole blood	
			0.0002-0.0002 ppm	0.0004 ppm	Red blood cells	
			0.0003-0.0014 ppm	0.0009 ppm	Serum	
	350 pairs	GC	0.5-6.0 ppb	NG	Mother-infant pairs in Mississippi	D'Ercole et al., 1976
	28	GC	0.5-3.4 ppb	NG	Lactating women	Dyment et al., 1971
	723	GC-EC	0.0-3.9 ppb	0.2 ppb	Urban and rural, whites and blacks	Finklea et al., 1972

Table 26. *o,p'*-Dichlorodiphenyltrichloroethane (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	8	GC	0.4-2.0 ppb	NG	Whole blood	Radomski et al., 1971
			0.7-2.2 ppb	NG	Plasma	
	202	GC-EC	0.0-2.0 ppb	<0.1 ppb	Serum	Wyllie, Gabica, and Benson, 1972
Brain	10	GC	NG	0.84 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
Heart	10	GC	0.57-0.68 ppm	0.63 ± 0.06 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
Kidney	10	GC	0.29-2.07 ppm	1.38 ± 0.55 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
Liver	10	GC	0.22-3.42 ppm	1.32 ± 1.05 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
Milk	10	GC-EC	<0.0001-0.0108 ppm	NG	Lactating women	Curley and Kimbrough, 1969
	28	GC	0.5-3.4 ppb	NG	Lactating women	Dyment et al., 1971
	6	GC-EC	0.003-0.036 ppm	NG	From pesticide use	Hagyard et al., 1973
	40	GC	Trace to 13.0 ppb, fat	1.8 ppb, fat basis	Females, rural Colorado	Savage et al., 1973
	920 of 1436	GC-EC	<1.0-6333.3 ppb, fat	191.1 ppb, fat basis	Nursing mothers, fat basis	Savage, 1976
Spinal cord	10	GC	NG	0.47 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969
Spleen	10	GC	0.45-2.94 ppm	1.70 ± 1.25 ppm	Stillborn babies	Curley, Copeland, and Kimbrough, 1969

Table 27. *p,p'*-Dichlorodiphenyltrichloroethane

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	NG	GC/MS	NG	7.65 ppm	Emphasis on methodology	Biros and Walker, 1970
	221	GC-EC	NG	3.48 ± 2.54 ppm	Agricultural area, Mexican-Americans higher content	Burns, 1974
	10	GC	0.16-2.15 ppm	0.88 ± 0.63 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969
	30	GC	<0.09-4.97 ppm	1.14 ppm	Washington, Arizona, and Kentucky	Dale and Quinby, 1963
	143	GC	NG	2.5 ± 1.1 ppm 0.8 ± 0.2 ppm 2.4 ± 0.8 ppm 0.8 ± 0.4 ppm	Female, black Female, white Male, black Male, white	Domanski et al., 1977
	71	GC-EC	Trace to 15.6 ppm	NG	Accidental deaths	Fiserova-Bergerova et al., 1967
	25	GC	0.15-5.99 ppm	1.73 ppm	General population in Los Angeles	Hayes, Dale, and Burse, 1965
	332	GC-EC	0.0-7.7 ± 8.0 ppm	NG	Autopsies, Miami, Florida, diseased and normal	Radomski et al., 1968
	64	GC-EC	0.1-30.3 µg/g, fat	4.8 µg/g, fat	Autopsies	Rappolt and Hale, 1968
	202	GC-EC	0.1-6.6 ppb	1.9 ppb	Surgical biopsies in Idaho	Wyllie, Gabica, and Benson, 1972
Bile	5	GC-EC	0.0-0.7 ppb	0.32 ppb	Elderly men, bile duct drainage, evidence of excretion by liver	Paschal, Roan, and Morgan, 1974
Blood	960	GC-EC	6.75-34.83 ppb	20.56 ppb	County of residence most significant factor, increase with age	Bloomer et al., 1977
	30	GC	0.0011-0.0155 ppm	0.0046 ppm	Cord blood	Curley, Copeland, and Kimbrough, 1969
	7	GC-EC	<0.0001-0.0222 ppm	NG	Pregnant women, plasma	Curley and Kimbrough, 1969
	20	GC	0.0114-0.0490 ppm 0.0024-0.0164 ppm 0.0030-0.0343 ppm 0.0023-0.0265 ppm 0.0068-0.0844 ppm 0.0057-0.0199 ppm	0.0253 ppm 0.0086 ppm 0.0153 ppm 0.0136 ppm 0.0248 ppm 0.0131 ppm	Plasma, males Plasma, females Red blood cells, males Red blood cells, females Whole blood, males Whole blood, females	Dale, Curley, and Cueto, 1966

Table 27. *p,p'*-Dichlorodiphenyltrichloroethane (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	10	GC-EC	0.0034-0.0305 ppm 0.0024-0.0106 ppm 0.0008-0.0049 ppm 0.0042-0.0290 ppm	0.0119 ppm 0.0058 ppm 0.0026 ppm 0.0105 ppm	Plasma Whole blood Red blood cells Serum	Dale, Curley, and Cueto, 1966
	10	GC-EC	NG	0.0077 ppm	Females, no occupational exposure	Dale, Curley, and Cueto, 1966
	800	GC-EC	<2.0-23.0 and 3.0-53.0 ppb	5.1 and 10.4 ppb	General population, Dade County, Florida, increase with age, blacks higher levels, serum	Davies et al., 1973
	350 pairs	GC	2.0-20.0 ppb	NG	Mother-infant pairs	D'Ercole et al., 1976
	28	GC	0.5-23.9 ppb	9.7 ppb	Lactating women, serum	Dyment et al., 1971
	723	GC	0-62.7 ppb	4.38 ppb	Urban and rural, blacks and whites	Finklea et al., 1972
	1619	GC	0.0-27 ppb	3.91 ppb	Urban and rural in Hawaii	Klemmer, Rashad, and Mi, 1973
	8	GC	3.6-8.9 ppb 5.6-16.5 ppb	4.18 ± 1.83 ppb	Whole blood Plasma	Radomski et al., 1971
	28	GC-EC	NG	4.18 ± 1.83 ppb	Autopsies and lab workers, Miami, Florida	Radomski et al., 1971
	3568	NG	NG	5.1 ± 5.1 ppb	General population in Hawaii, serum	Rashad et al., 1976
	24	GC-EC			Males, ages 33-68 years, serum:	Watson et al., 1973
			3.0-18.0 ppb 4.0-40.0 ppb	8.5 ppb 13.4 ppb	1970 1971	
	1000	GC-EC	0.0-80.0 ppb	4.7 ppb	General population in Idaho	Watson, Benson, and Gabica, 1970
	202	GC-EC	0.0-14.0 ppb	4.0 ppb	Surgical biopsies in Idaho	Wyllie, Gabica, and Benson, 1972
Brain	10	GC	0.28-0.99 ppm	0.56 ± 0.22 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969
	71	GC-EC	0.00-0.44 ppm	NG	Accidental deaths	Fiserova-Bergerova et al., 1967
	332	GC-EC	0.0-0.04 ± 0.01 ppm	NG	Autopsies, Miami, Florida, diseased and normal	Radomski et al., 1968

Table 27. *p,p'*-Dichlorodiphenyltrichloroethane (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Gonads	71	GC-EC	0.00-0.19 ppm	NG	Accidental deaths	Fiserova-Bergerova et al., 1967
Heart	10	GC	1.04-4.17 ppm	2.17 ± 0.69 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969
Kidney	10	GC	0.62-7.60 ppm	3.71 ± 1.70 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969
Liver	NG	GC/MS	NG	0.45 ppm	Emphasis on methodology	Biros and Walker, 1970
	10	GC	0.15-1.59 ppm	0.79 ± 0.24 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969
	71	GC-EC	0.00-0.96 ppm	NG	Accidental deaths	Fiserova-Bergerova et al., 1967
	332	GC-EC	0.0-0.53 ± 0.14 ppm	NG	Autopsies, Miami, Florida, diseased and normal	Radomski et al., 1968
Lung	10	GC	0.57-1.01 ppm	0.79 ± 0.11 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969
Milk	10	GC-EC	0.0078-0.0890 ppm	NG	Lactating women	Curley and Kimbrough, 1969
	28	GC	4.0-47.8 ppb	23.4 ppb	Rural and urban areas in Texas	Dyment et al., 1971
	28	GC	4.0-56.6 ppb	23.4 ppb	Relation between milk and serum	Dyment et al., 1971
	6	GC-EC	0.017-0.383 ppm	NG	From pesticide use	Hagyard et al., 1973
	1436	GC-EC	<1.0-34,369.3 ppb	552.7 ppb	11 of 1436, none detected, fat basis	Savage, 1976
	40	GC	7.0-109.0 ppb	20.8 ppb	Females, rural county, fat basis	Savage et al., 1973
	57	GC-EC, GC/MS	0.01-0.84 ppm	0.092 ppm	From selected areas of Mississippi and Arkansas, 1973-1974, 27% blacks, whole-milk basis	Strassman and Kutz, 1977
Pancreas	10	GC	NG	0.49 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969
Spinal cord	10	GC	NG	0.47 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969

Table 27. p,p'-Dichlorodiphenyltrichloroethane (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Spleen	10	GC	0.48-1.04 ppm	0.80 ± 0.17 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969
Urine	221	GC-EC	8.1-19.0 ppb	14.2 ppb	General population of Florida	Cranmer, Carroll, and Copeland, 1969
	10	GC	<0.0018-0.0138 ppm	NG	Comparison of recoveries	Cueto and Biros, 1967

Table 28. Dichlorodiphenyltrichloroethane, total equivalent

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	221	GC-EC	NG	23.18 ± 15.36 ppm	Tissues from surgery, agricultural area, Texas, 1969-1972	Burns, 1974
	90	GC-EC	1.9-21.1 ppm	7.9 ppm (median)	Patients in Florida hospital	Davies et al., 1969
	42	NG	NG	9.7 ppm	Accidental deaths	Deichman and MacDonald, 1971
	31	NG	NG	9.4 ppm	Sparing users of home pesticides	Deichman and MacDonald, 1971
	65	NG	NG	19.4 ppm	Moderate users	Deichman and MacDonald, 1971
	22	NG	NG	27.0 ppm	Careless users	Deichman and MacDonald, 1971
	1412	GC-EC	0.0-270.05 ppm	11.65 ppm	Reflects the levels in the U.S. population of the conterminous 48 states, 1970, lipid basis	Kutz et al., 1974*b*
	6933	GC-EC	Trace to 329.77 ppm	7.88-4.99 ppm (geometric mean), FY 1970-FY 1974; high mean in FY 1971, 7.95 ppm	U.S. sites reflective of general population in conterminous 48 states, FY 1970-FY 1974, lipid basis; decline FY 1971-FY 1974	Kutz, Strassman, and Yobs, 1976, 1977; Kutz et al., 1977
	1734	GC-EC	330, 89.1 ppm (max), 1973, 1974	5.53, 4.65 ppm, 1973, 1974 (geometric mean)	Whites and blacks respectively. Reflective of general U.S. population in conterminous 48 states, lipid basis	Kutz, Yobs, and Strassman, 1977
	240	GC-EC	78.1, 76.4 ppm (max), 1973, 1974	9.38, 8.33 ppm, 1973, 1974 (geometric mean)		
Blood	960	GC-EC	9.93-46.89 ppb	28.86 ppb	Michigan counties, 1968-1970	Bloomer et al., 1977
	209 pairs	GC	NG	110 and 40 ppb	Rural area, Mississippi, 1972, black mothers and newborns	D'Ercole et al., 1976
	130 pairs	GC	NG	45 and 20 ppb	White mothers and newborns, serum	D'Ercole et al., 1976
	NG	GC-EC	0.005-0.030 ppm	0.017 ppm	Cotton-growing area, Mississippi, mosquito spraying and house use of insecticides, 1968, serum	Perron and Barrentine, 1970
	53	GC-EC	0.8-50.4 ppb	5.01 ppb (geometric mean)	Maternal blood, 53 mothers, Louisiana, 36 rural, 16 urban, 1966-1967	Selby, Newell, Hauser, and Junker, 1969

Table 28. Dichlorodiphenyltrichloroethane, total equivalent (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Feces	32	GC	Trace to 3.7 µg/day per person	NG	Preadolescent girls	Price, Young, and Dickinson, 1972
Hair	9	GC	0.01-0.10 ppm	0.06 ppm (median)	Excretion of dichlorodiphenyltrichloroethane and metabolites in hair lipids	Matthews, Domanski, and Guthrie, 1976
Milk	6	GC-FC	0.093-0.575 ppm	NG	Mothers in Arizona	Hagyard et al., 1973
	57	GC-EC, GC/MS	0.02-2.76 ppm	0.344 ppm	Mothers in selected areas of Arkansas and Mississippi where 2,4,5-T was used, whole-milk basis, 27% blacks, 1973-1974	Strassman and Kutz, 1977
Placenta	53	GC-EC	1.8-179.3 ppb	24.07 ppb (geometric mean)	53 newborns, Louisiana, 1966-1967	Selby, Newell, Hauser, and Junker, 1969
Urine	32	GC	Trace to 2.1 µg/day per person	NG	Preadolescent girls	Price, Young, and Dickinson, 1972

Table 29. Dieldrin

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	NG	GC/MS	NG	1.04 ppm	Emphasis on methodology	Biros and Walker, 1970
	221	GC-EC	NG	0.35 ± 0.23 ppm	Agricultural area, no sex differences, Mexican-Americans higher content	Burns, 1974
	30	GC-EC	NG	0.06-0.17 ppm	Random samples, ages 28 weeks to 88 years	Casarett et al., 1968
	10	GC	0.09-0.35 ppm	0.24 ± 0.08 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969
	30	GC	<0.02-0.36 ppm	0.15 ppm	Washington, Arizona, and Kentucky	Dale and Quinby, 1963
	11	GC-EC	0.08-0.38 ppm	0.17 ppm	Controls for phenytoin experiment	Davies et al., 1971
	215	GC-EC	0.21-0.73 ppm	NG	Autopsies, Dade County, Florida	Deichman and Radomski, 1968
	14	GC	NG	0.22 ppm	Black females, smokers	Domanski et al., 1977
	20	GC	NG	0.25 ppm	Black females, nonsmokers	
	10	GC	NG	0.24 ppm	White females, smokers	
	17	GC	NG	0.21 ppm	White females, nonsmokers	
	20	GC	NG	0.3 ppm	Black males, smokers	
	14	GC	NG	0.22 ppm	Black males, nonsmokers	
	35	GC	NG	0.24 ppm	White males, smokers	
	13	GC	NG	0.20 ppm	White males, nonsmokers Enzymes induced reduce level	
	146	GC-EC	<0.05-0.77 ppm	0.22 ppm	Autopsies in Florida	Edmundson, Davies, and Hull, 1968
	25	GC	0.03-1.15 ppm	0.29 ± 0.05 ppm		Hayes, Dale, and Burse, 1965
	64	GC	0.05-1.00 ppm	0.11 ppm		Hoffman, Harrison, and Schaefer, 1964
	221	GC	0.01-0.49 ppm	0.14 ppm	118 of 221 positives	Hoffman et al., 1967
	NG	NG	NG	0.26 mg/kg		Hunter, Robinson, and Jager, 1967
	NG	GC-EC	0.0-15.2 ppm	0.27 ppm	Reflects the levels in the U.S. population of the conterminous 48 states, 1970, lipid basis	Kutz et al., 1974*b*
	1734	GC-EC	Trace to 5.64 ppm	0.17, 0.15 ppm, 1973 1974 (geometric mean)	Whites and blacks respectively. Reflective of general U.S. population in conterminous 48 states, lipid basis	Kutz, Yobs, and Strassman, 1977
	240	GC-EC	Trace to 3.09 ppm	0.21, 0.16 ppm, 1973 1974 (geometric mean)		

Table 29. Dieldrin (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	6932	GC-EC	Trace to 15.20 ppm	0.18-0.15 ppm (geometric mean), FY 1970-FY 1974; high mean FY 1971, 0.22 ppm	U.S. sites reflective of the general population in conterminous 48 states, FY 1970-1974, lipid basis	Kutz, Strassman, and Yobs, 1976, 1977
	70	GC-EC	NG	0.140 ppm	Autopsies, Arizona	Morgan and Roan, 1970
	332	GC-EC	NG	0.21 ± 0.16 and 0.73 ± 0.59 ppm	Autopsies, Florida	Radomski et al., 1968
	103	GC	NG	0.17 ppb	Utah	Warnick, 1972
	202	GC-EC	0.0-0.7 ppb	0.2 ppb	Surgical biopsies in Idaho	Wyllie, Gabica, and Benson, 1972
Adrenal	18	GC-EC	NG	0.10 ppm, fat	Random samples, ages 28 weeks to 88 years	Casarett et al., 1968
	10	GC	NG	0.92 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969
Blood	960	GC-EC	0.0-0.38 ppb	0.23 ppb	Reflect pesticide usage in Missouri	Bloomer et al., 1977
	30	GC	0.0002-0.0015 ppm	0.0007 ± 0.0001 ppm	Cord blood	Curley, Copeland, and Kimbrough, 1969
	7	GC-EC	<0.0001-0.0061 ppm	NG	Pregnant women, plasma	Curley and Kimbrough, 1969
	20	GC	<0.0012-0.0063 ppm <0.0012-0.0072 ppm 0.0021-0.0069 ppm 0.0014-0.0108 ppm 0.0010-0.0129 ppm 0.0006-0.0045 ppm	0.0028 ppm 0.0009 ppm 0.0043 ppm 0.0049 ppm 0.0055 ppm 0.0018 ppm	Plasma, males Plasma, females RBC, males RBC, females Whole blood, males Whole blood, females	Dale, Curley, and Hayes, 1967
	10	GC-EC	NG	0.0013 ppm	Blood serum	Dale, Curley, and Cueto, 1966
	10	GC-EC	0.0009-0.0037 ppm	0.0019 ppm	Whole blood, RBCs less	Dale, Curley, and Cueto, 1966
	800	GC-EC	<1.0-11.0 ppb <1.0-5.0 ppb	1.40 ppb 1.05 ppb	General population, Dade County, Florida: whites blacks	Davies et al., 1973
	350 pairs	GC	0.1-0.7 ppb	NG	Mississippi blacks and whites, mother-infant pairs, blood serum	D'Ercole et al., 1976

Table 29. Dieldrin (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	28	GC	0.0-6.0 ppb	1.2 ppb	Blood serum	Dyment et al., 1971
	723	GC-EC	0-6.9 ppb	0.28 ppb	Urban and rural, blacks and whites	Finklea et al., 1972
	115	GC-EC	NG	2.15 ppb	General population, Hawaii, blood serum	Klemmer et al., 1977
	116	GC	0.0-26.0 ppb	1.5 ppb	General population, Hawaii, serum	Klemmer, Rauhad, and Mi, 1973
	91	GC	0-5.5 ppb	1.30 ppb	Maternal blood	Lloyd et al., 1975
	28	GC	0.5-1.4 ppb 0.7-3.3 ppb	1.49 ± 1.0 ppb	Whole blood Plasma	Radomski et al., 1971
	3568	NG	NG	2.4 ± 1.4 ppb	General population, Hawaii	Rauhad et al., 1976
	53 pairs	GC-EC	0.1-1.9 ppb	0.26 ppb (geometric mean)	Maternal blood, mother-infant pairs in Louisiana	Selby, Newell, Hauser, and Junker, 1969
	1417	GC	NG	1.8 ppb	Blood serum	Warnick, 1972
	1000	GC-EC	0.0-25.0 ppb	0.5 ppb 0.3 ppb 1.3 ppb	Blood serum: overall mean males females	Watson, Benson, and Gabica, 1970
	202	GC-EC	0.0-10.0 ppb	0.9 ppb	Surgical patients in Idaho, blood serum	Wyllie, Gabica, and Benson, 1972
Bone	30	GC-EC	NG	0.41 ppm, fat	Random samples, ages 28 weeks to 88 years, marrow	Casarett et al., 1968
Brain	32	GC-EC	NG	0.4 ppm, fat	Random samples, ages 28 weeks to 88 years	Casarett et al., 1968
	10	GC	0.84-0.86 ppm	0.85 ± 0.01 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969
	332	GC-EC	NG	0.04 ± 0.01 ppm	Autopsies, Florida	Radomski et al., 1968
Endometrium	15	GC-EC	0.0-7.8 ppb	0.6 ppb	General population, Hawaii	Klemmer et al., 1977
Fetal	15	GC-EC	0.0-4.9 ppb	0.7 ppb	Infants in Hawaii	Klemmer et al., 1977
Gonad	36	GC-EC	NG	0.62 ppm, fat	Random samples, ages 28 weeks to 88 years	Casarett et al., 1968
Hair	5	GC	NG	$\leq$0.01 ppm	Hair as excretory pathway	Matthews, Domanski, and Guthrie, 1976

Table 29. Dieldrin (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Heart	10	GC	0.08-1.02 ppm	0.49 ± 0.28 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969
Human	77	GC-EC	2.0-63.0 ppb	NG	General population, Hawaii	Klemmer et al., 1977
Kidney	38	GC-EC	NG	0.66 ppm, fat	Random samples, ages 28 weeks to 88 years	Casarett et al., 1968
	10	GC	0.06-0.50 ppm	0.34 ± 0.14 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969
Liver	NG	GC/MS	NG	0.34 ppm	Emphasis on methodology	Biros and Walker, 1970
	42	GC-EC	NG	0.43 ppm, fat	Random samples, ages 28 weeks to 88 years	Casarett et al., 1968
	10	GC	0.16-0.22 ppm	0.19 ± 0.03 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969
	332	GC-EC	NG	0.10 ± 0.19 ppm	Autopsies, Florida	Radomski et al., 1968
Lung	25	GC-EC	NG	0.16 ppm, fat	Random samples, ages 28 weeks to 88 years	Casarett et al., 1968
	10	GC	0.27-0.72 ppm	0.50 ± 0.23 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969
Lymph nodes	11	GC-EC	NG	0.11 ppm, fat	Random samples, ages 28 weeks to 88 years	Casarett et al., 1968
Milk	10	GC-EC	0.0029-0.0146 ppm	NG	Lactating women	Curley and Kimbrough, 1969
	28	GC	0.0-21.0 ppb	3.3 ppb	Milk not good indicator source	Dyment et al., 1971
	6	GC-EC	0.0-12.0 ppb	3.0 ppb	Females in Hawaii	Klemmer et al., 1977
	40	GC	0.0-11.0 ppb	1.7 ppb, fat basis	Females in Colorado	Savage et al., 1973
	1160	GC-EC	1.0->2294 ppb	164.2 ppb, fat basis	1160 of 1436 positives	Savage, 1976
	57	GC-EC, GC/MS	Trace to 0.05 ppm	0.004 ppm (trace = 0)	Selected areas of Mississippi and Arkansas, 1973-1974, 27% blacks, whole-milk basis	Strassman and Kutz, 1977
Spinal cord	10	GC	NG	0.09 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969
Spleen	27	GC-EC	NG	1.8 ppm, fat	Random samples, ages 28 weeks to 88 years	Casarett et al., 1968

Table 29. Dieldrin (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	10	GC	0.18–0.51 ppm	0.31 ± 0.10 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969
Urine	10	GC	0.0005–0.0019 ppm	0.001 ppm	Men slightly higher than women	Cueto and Biros, 1967

Table 30. Diethylhexyl phthalate

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Lung	12	TLC	0.0-91.5 µg/g dry wt	NG	From blood transfusion plastic devices	Jaeger and Rubin, 1973

Table 31. Dysprosium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.0-0.26 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964

Table 32. Erbium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRSCh	0.00-0.08 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964

Table 33. Europium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00-0.52 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964

Table 34. Fluorine

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Aorta	23	NG	0.79-65.7 ppm wet wt	2.13-37.9 ppm wet wt	Autopsy of normals: first mean value, zero fluorine in water second mean value, 4.0 ppm fluorine in water	Hodge and Smith, 1965
	16-23	NG	2.64-166.3 ppm dry wt	22.04 ppm dry wt (median)		Smith et al., 1960
	23	Ch	0.0-20.3 ppm 0.0-165.1 ppm	6.0 ppm 40.6 ppm	Less calcified aortas Calcified aortas	Waldbott, 1966
Blood	8 maternal 7 infant	ISE			Methoxyflurane analgesia and anesthesia, blood serum:	Fry and Taves, 1974
			0.8-26.5 μM 1.0-5.1 μM 2.3-327.0 μM 4.7-34.0 μM	11.3 μM 2.86 μM 99.7 μM 16.8 μM	maternal, inorganic fluorine infant, inorganic fluorine maternal, organic fluorine infant, organic fluorine	
			0.9-25.2 μM 1.3-3.3 μM 0.1-445.0 μM 1.7-35.0 μM	10.7 μM 2.1 μM 150.0 μM 12.3 μM	Anesthesia, higher dose: maternal, inorganic fluorine infant, inorganic fluorine maternal, organic fluorine infant, organic fluorine	
	NG	NG	NG	0.165 ± 0.07 ppm 0.175 ± 0.05 ppm	Fetal blood: low fluorine intake high fluorine intake	Gedalia, 1970
	NG	NG	NG	0.150 ± 0.06 ppm 0.234 ± 0.10 ppm	Maternal blood: low fluorine intake high fluorine intake	Gedalia, 1970
	NG	ISE	0.08-4.17 μM 0.18-6.80 μM	0.78 μM 1.57 μM	Blood serum: inorganic fluorine organic fluorine	Guy and Taves, 1972
	5	NMR	NG	1.6 μM	Blood plasma, five cities	Guy, Taves, and Brey, 1975
	41	ISE	0.019-0.112 ppm	0.47 ppm	In-patients, ages 17-82, blood plasma	Parkins et al., 1976
	NG	NG	NG	0.32 μg/ml		Rentoul and Smith, 1973
	16 pairs	ISE, Ch	NG	0.88 ± 0.12 μM 0.68 ± 0.10 μM	Maternal serum Cord blood	Shen and Taves, 1974
	6	ISE, C	0.06-0.14 ppm ash	NG		Singer and Armstrong, 1969

Table 34. Fluorine (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	118	NG	0.14-0.26 ppm	NG	Five areas with varied fluorine content of water	Singer and Armstrong, 1960
	NG	NG	NG	0.0006 g fluorine	Whole blood fluorine content	Smith, 1966
	16	F	NG	0.013 ppm or 0.7 ± 0.4 μM	Blood serum	Taves, 1966
	106	NG	NG	1.35 ± 0.85 μM 0.38 ± 0.21 to 4.3 ± 1.8 μM	Blood serum: organic fluorine inorganic fluorine and low fluorine water and inorganic fluorine and high fluorine water	Taves, Grey, and Brey, 1976
	NG	Ch	NG	0.013 ppm	Blood serum	Taves, 1966
	106	NG	0.38 ± 0.21 to 4.3 ± 1.8 μM 1.35 ± 0.85 μM	NG	Inorganic fluorine Organic fluorine	Taves, Grey, and Brey, 1976
Bone	NG	NG	NG	800 ppm dry, defatted basis	Chicago area autopsies	Hefferen et al., 1972
	NG	NG	100-4000 ppm dry, fat-free tissue	NG	High and low fluorine areas, iliac crest	Hodge and Smith, 1970
	11	NG	0.052-0.134% ash 0.031-0.142% ash 0.057-0.191% ash	0.093% ash 0.084% ash 0.125% ash	Mandible Femur Iliac crest	Singer and Armstrong, 1962
	NG	NG	NG	2.547 g fluorine	Total fluorine in bones and teeth	Smith, 1966
	11	Ch	1165-1490 ppm ash	NG	Root bone	Yoon et al., 1960
	NG	NG	0.08-0.69% ash 0.08-0.70% ash 0.10-0.80% ash	NG	Iliac crest Rib Vertebra	Zipkin, 1970
	69	C	0.072-0.802 ppm ash	NG		Zipkin, 1960
Brain	NG	NG	NG	2.0 μg/g dry wt		Rentoul and Smith, 1973
Extracellular fluid	NG	NG	NG	0.002 g fluorine	Total	Smith, 1966
Heart	23	NG	0.32-2.14 ppm wet wt	0.55-1.29 ppm wet wt	Autopsy of normals: first mean value, zero fluorine in water second mean value, 4.0 ppm fluorine in water	Hodge and Smith, 1965

Table 34. Fluorine (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	NG	NG	NG	2.0 µg/g dry wt		Rentoul and Smith, 1973
	16-23	NG	1.19-23.3 ppm dry wt	2.42 ppm dry wt (median)	Various levels of fluorine in drinking water	Smith et al., 1960
Kidney	23	NG	0.30-5.45 ppm wet wt	0.63-2.55 ppm wet wt	Autopsy of normals: first mean value, zero fluorine in water second mean value, 4.0 ppm fluorine in water	Hodge and Smith, 1965
	NG	NG	NG	3.2 µg/g dry wt		Rentoul and Smith, 1973
	16-23	NG	1.35-25.6 ppm dry wt	4.01 ppm dry wt (median)	Various levels of fluorine in drinking water	Smith et al., 1960
Liver	23	NG	0.27-1.47 ppm wet wt	0.52-0.92 ppm wet wt	Autopsy of normals: first mean value, zero fluorine in water second mean value, 4.0 ppm fluorine in water	Hodge and Smith, 1965
	NG	NG	NG	4.0 µg/g dry wt		Rentoul and Smith, 1973
	16-23	NG	0.92-5.41 ppm dry wt	2.14 ppm dry wt (median)	Various levels of fluorine in drinking water	Smith et al., 1960
Lung	23	NG	0.54-2.91 ppm wet wt	0.71-1.98 ppm wet wt	Autopsy of normals: first mean value, zero fluorine in water second mean value, 4.0 ppm fluorine in water	Hodge and Smith, 1965
	16-23	NG	1.79-12.4 ppm dry wt	4.34 ppm dry wt (median)	Various levels of fluorine in drinking water	Smith et al., 1960
Milk	NG	Ch	0.0-0.6 ppm	NG	Higher values for mothers living near superphosphate plant	Smith, 1966
Muscle	NG	NG	NG	0.016 g fluorine	Total fluorine in muscle and skin	Smith, 1966
Placenta	NG	NG	NG	0.121 ± 0.06 ppm 0.228 ± 0.09 ppm	Low fluorine intake High fluorine intake	Gedalia, 1970
	16 pairs	ISE, Ch	1.9-8.1 µM 6.6-103.6 µM	4.42 µM 46.4 µM	Organic fluorine Inorganic fluorine	Shen and Taves, 1974

Table 34. Fluorine (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Skin	NG	NG	NG	0.016 g fluorine	Total fluorine in skin and muscles	Smith, 1966
Spleen	23	NG	0.31-1.19 ppm wet wt	0.51-0.82 ppm wet wt	Autopsy of normals: first mean value, zero fluorine in water second mean value, 4.0 ppm fluorine in water	Hodge and Smith, 1965
	16-23	NG	1.34-16.7 ppm dry wt	3.43 ppm dry wt (median)	Various levels of fluorine in drinking water	Smith et al., 1960
Teeth	18	NG	NG	56 ppm 98 ppm	Enamel Dentin	Anonymous, 1959
	35	AAS	970-3120 ppm	2160 ± 550 ppm	School children, left maxillary incisor	Brudevold et al., 1975
	208	MS	NG		Subjects less than 20 years old:	Curzon and Losee, 1977
				73.9 ± 5.95 ppm	high caries area, New England	
				126.7 ± 8.63 ppm	low caries area, South Carolina	
	12	XRS	27.1-748.8 ppm	NG	Normals, 17-24 years old, enamel	Hoerman et al., 1966
	87	ISE	NG		Children, 12-14 years old;	Little and Barrett, 1976
				478-832 ppm	premolar tooth enamel	
				302-529 ppm	tooth surface	
				170-310 ppm	subsurface	
				41-177 ppm	inner bulk	
	56	MS	70-730 µg/g	248 ± 20 µg/g	Subjects less than 20 years old, wide geographic area	Losee, Cutress, and Brown, 1973
	11	NG	0.0067-0.0245% ash	0.0107% ash	Enamel	Singer and Armstrong, 1962
			0.0370-0.0990% ash	0.0620% ash	Dentin	
			0.104-0.212% ash	0.1580% ash	Cementum	
	NG	NG	NG	2.547 g fluorine	Total fluorine in bones and teeth	Smith, 1966
	18 groups	ISE	0.234-0.774 ppm	NG	Cementum	Stepnick, Nakata, and Zipkin, 1975
	11	Ch	62-2721 ppm ash	NG		Yoon et al., 1960

Table 34. Fluorine (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Urine	NG	NAA	0.39-0.43 mg/liter	0.41 mg/liter		Gills et al., 1974
	1998	Ch	0.2-4.8 ppm	NG	Males, 15-20 years old	McClure and Kinser, 1944
	16 pairs	ISE, Ch	NG	54 ± 6.8 ppm	Maternal	Snen and Taves, 1974

Table 35. Gadolinium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00-0.26 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964

Table 36. Gallium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
ood	39	XRS	0.0-0.09 ppm	NG	Healthy males, mean age 35.3 years, blood serum	Gofman et al., 1964
ng	2	ES	NG	3.5 and 6.0 μg/g ash	Sudden accident victims, normal	Koch et al., 1956

Table 37. Germanium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00-0.10 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964
	4	C	NG	0.29 µg/ml	Serum	Schroeder and Balassa, 1967
	4	C	NG	0.65 µg/ml	Red blood cells	Schroeder and Balassa, 1967
Urine	4	C	0.62-2.16 µg/ml	1.26 µg/ml		Schroeder and Balassa, 1967

Table 38. Gold

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adrenal	6 of 15	ES	<10-60 μg/g ash	<10 μg/g ash (median)	Adults	Tipton and Cook, 1963
Aorta	27 of 105	ES	<10-40 μg/g ash	<10 μg/g ash (median)	Adults	Tipton and Cook, 1963
Bladder	22 of 122	ES	<10-30 μg/g ash	<10 μg/g ash (median)	Adults	Tipton and Cook, 1963
Blood	39	XRS	0.0-0.23 ppm	NG	Healthy males, mean age 35.3 years, blood serum	Gofman et al., 1964
	NG	NG	NG	0.00004 μg/ml		Rentoul and Smith, 1973
Brain	NG	NG	NG	0.5 μg/g dry wt		Rentoul and Smith, 1973
	1 of 129	ES	<10-40 μg/g ash	<10 μg/g ash (median)	Adults	Tipton and Cook, 1963
Diaphragm	9 of 91	ES	<10-40 μg/g ash	<10 μg/g ash (median)	Adults	Tipton and Cook, 1963
Esophagus	18 of 68	ES	<10-22 μg/g ash	<10 μg/g ash (median)	Adults	Tipton and Cook, 1963
Hair	33	NAA	0.08×10^{-2} to 27.0×10^{-2} ppm	4.3×10^{-2} ppm	Children and adults, Oak Ridge, Tennessee	Bate and Dyer, 1965
	33	NAA	NG	0.67 μg/g		Mahler et al., 1970
	10	NAA	NG	0.0267 ± 0.0046 ppm		Obrusnik et al., 1972
	NG	NG	NG	0.05 μg/g dry wt		Rentoul and Smith, 1973
Heart	NG	NG	NG	0.00013 μg/g dry wt		Rentoul and Smith, 1973
	6 of 140	ES	<10-40 μg/g ash	<10 μg/g ash (median)	Adults	Tipton and Cook, 1963
Intestine						
Duodenum	13 of 68	ES	<10-20 μg/g ash	<10 μg/g ash (median)	Adults	Tipton and Cook, 1963
Jejunum	19 of 104	ES	<10-25 μg/g ash	<10 μg/g ash (median)	Adults	Tipton and Cook, 1963
Ileum	21 of 84	ES	<10-33 μg/g ash	<10 μg/g ash (median)	Adults	Tipton and Cook, 1963
Cecum	6 of 31	ES	<10-20 μg/g ash	<10 μg/g ash (median)	Adults	Tipton and Cook, 1963
Sigmoid colon	6 of 31	ES	<10-25 μg/g ash	<10 μg/g ash (median)	Adults	Tipton and Cook, 1963
Rectum	3 of 42	ES	<10-<10 μg/g ash	<10 μg/g ash (median)	Adults	Tipton and Cook, 1963
Kidney	NG	NG	NG	0.5 μg/g dry wt		Rentoul and Smith, 1973
	15 of 145	ES	<10-10 μg/g ash	<10 μg/g ash (median)	Adults	Tipton and Cook, 1963
Larynx	3 of 50	ES	<10-<10 μg/g ash	<10 μg/g ash (median)	Adults	Tipton and Cook, 1963

Table 38. Gold (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Liver	NG	NG	NG	0.0001 μg/g dry wt		Rentoul and Smith, 1973
	4 of 150	ES	<10-<10 μg/g ash	<10 μg/g ash (median)	Adults	Tipton and Cook, 1963
Lung	3 of 141	ES	<10-22 μg/g ash	<10 μg/g ash (median)	Autopsies	Tipton and Cook, 1963
	3 of 141	ES	<10-<10 μg/g ash	<10 μg/g ash (median)	Adults	Tipton and Cook, 1963
Muscle	4 of 137	ES	<10-<10 μg/g ash	<10 μg/g ash (median)	Adults	Tipton and Cook, 1963
Omentum	NG	ES	7-220 μg/g ash	30 μg/g ash (median)	Adults	Tipton and Cook, 1963
Ovary	5 of 16	ES	<10-23 μg/g ash	<10 μg/g ash (median)	Adults	Tipton and Cook, 1963
Nail	6	NAA	0.0-1.52 μg/g	0.44 ± 0.60 μg/g	Children	Kanabrocki et al., 1968
	13		0.0-2.05 μg/g	0.52 ± 0.58 μg/g	Adults	
	13	NAA	NG	0.171 μg/g	Fingernail	Mahler et al., 1970
Pancreas	138	ES	18-130 μg/g ash	49 μg/g ash (median)	Adults	Tipton and Cook, 1963
Prostate	44 of 50	ES	<5-81 μg/g ash	10 μg/g ash (median)	Adults	Tipton and Cook, 1963
Saliva	15	NAA	0.01-0.64 μg/100 ml	0.06 ± 0.02 μg/100 ml		Kanabrocki et al., 1965*b*
Spleen	138 of 143	ES	7-90 μg/g ash	27 μg/g ash (median)	Adults	Tipton and Cook, 1963
Skin	21 of 22	ES	16-120 μg/g ash	46 μg/g ash (median)	Adults	Tipton and Cook, 1963
Stomach	123 of 131	ES	5-35 μg/g ash	12 μg/g ash (median)	Adults	Tipton and Cook, 1963
Testis	123 of 131	ES	5-27 μg/g ash	12 μg/g ash (median)	Adults	Tipton and Cook, 1963
Thyroid	20 of 21	ES	5-54 μg/g ash	12 μg/g ash (median)	Adults	Tipton and Cook, 1963
Trachea	60	ES	15-120 μg/g ash	44 μg/g ash (median)	Adults	Tipton and Cook, 1963
Uterus	1 of 32	ES	<10-<10 μg/g ash	<10 μg/g ash (median)	Adults	Tipton and Cook, 1963

Table 39. Hafnium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00-0.41 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964

Table 40. Heptachlor

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	106	GC-EC	0.1-0.2 ppb	0.13 ppb	53 mother-infant pairs	Selby, Newell, Hauser, and Junker, 1969
	106	GC-EC	0.1-0.8 ppb	0.21 ppb	53 mother-infant pairs	
Milk	1436	GC-EC	NG	NG	Found in <2%	Savage, 1976
Placenta	106	GC-EC	2.0-52.0 ppb	6.23 ppb	53 mother-infant pairs	Selby, Newell, Hauser, and Junker, 1969
	106	GC-EC	0.1-54.9 ppb	2.12 ppb	53 mother-infant pairs	

Table 41. Heptachlorepoxide

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	221	GC-EC	NG	0.11 ± 0.11 ppm	From surgeries	Burns, 1974
	30	GC-EC	NG	0.04 ppm	Fat basis, perirenal fat	Casarett et al., 1968
	29	GC-EC	NG	0.05 ppm	Fat basis, mesenteric fat	Casarett et al., 1968
	30	GC-EC	NG	0.05 ppm	Fat basis, panniculus fat	Casarett et al., 1968
	10	GC	0.07-0.51 ppm	0.32 ± 0.10	Stillbirths	Curley, Copeland, and Kimbrough, 1969
	25	GC-EC	0.01-0.14 ppm 0.02-0.09 ppm	0.05 ppm 0.05 ppm	Phenytoin (14 cases) Control groups (11)	Davies et al., 1971
	25	GC	0.03-1.45 ppm	0.24 ± 0.05 ppm		Hayes, Dale, and Burse, 1965
	505	GC	0.10-0.29 ppm	0.16 ppm	Autopsies, abdominal wall	Hoffman et al., 1967
	53	GLC	0.04-0.46 mg/kg	0.25 mg/kg	Nursing mothers in Philadelphia area, milk fat	Kroger, 1972
	1412	GC-EC	0.0-10.62 ppm	0.17 ppm	Reflects the levels in the U.S. population of the conterminous 48 states, lipid basis	Kutz et al., 1974*b*
	3964	GC-EC, TLC, MS	NG	0.09 ppm 0.08 ppm	1973 (2177 cases) 1974 (1787 cases)	Kutz, Strassman, and Yobs, 1977
	6933	GC-EC	Trace to 10.62 ppm	Geometric mean: 0.09 ppm, FY 1970-FY 1973; 0.08 ppm, FY 1974	U.S. sites reflective of the general population in the conterminous 48 states, FY 1970-FY 1974, lipid basis	Kutz, Strassman, and Yobs, 1976, 1977
	1734	GC-EC	Trace to 0.85 ppm	0.09, 0.08 ppm, 1973 1974 (geometric mean)	Whites and blacks respectively. Reflective of general U.S. population in conterminous 48 states, lipid basis	Kutz, Yobs, and Strassman, 1977
	240	GC-EC	Trace to 0.67 ppm	0.10, 0.07 ppm, 1973 1974 (geometric mean)		
	332	GC-EC	NG	0.16-1.12 ppm	Autopsies, diseased organs	Radomski et al., 1968
	202	GC-EC	0-1.3 ppb	0.1 ppb	White males and females, abdominal fat	Wyllie, Gabica, and Benson, 1972
Adrenal	18	GC-EC	NG	0.01 ppm	Fat basis	Casarett et al., 1968
	10	GC	0.46-1.00 ppm	0.73 ± 0.27	Stillbirths	Curley, Copeland, and Kimbrough, 1969
Blood	30	GC	0.0002-0.0043 ppm	0.0011 ± 0.0002	Cord blood	Curley, Copeland, and Kimbrough, 1969

Table 41. Heptachlorepoxide (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	7	GC-EC	<0.0001-0.0033 ppm	NG	Pregnant women, plasma	Curley and Kimbrough, 1969
	10	GC-EC	NG	0.0008 ppm	Women, serum	Dale, Curley, and Cueto, 1966
	10	GC-EC	0.0002-0.0031 ppm	0.0011 ppm	Plasma	Dale, Curley, and Cueto, 1966
	10	GC-EC	0.0004-0.0019 ppm	0.0008 ppm	Blood	
	10	GC-EC	0.0004-0.0010 ppm	0.0007 ppm	Red blood cells	
	10	GC-EC	0.0006-0.0028 ppm	0.0012 ppm	Serum	
	20	GC-EC			Red blood cells:	Dale, Curley, and Hayes, 1967
			<0.0006-0.0036 ppm	0.0012 ± 0.0004 ppm	Males (10)	
			<0.0003-0.0026 ppm	0.0008 ± 0.0003 ppm	Females (10)	
			<0.0003-0.0120 ppm	0.0023 ppm	Males (10)	
			0.0005-0.0051 ppm	0.0022 ppm	Females (10)	
	678	GC	0.01-0.1 ppb	NG	209 black and 130 white mother-infant pairs, serum	D'Ercole et al., 1976
	2 of 28	GC	1.0-1.8 ppb	NG	Lactating women, serum	Dyment et al., 1971
	53	GC-EC	0.1-0.6 ppb	0.21 ppb	Mother-infant pairs, maternal blood	Selby, Newell, Hauser, and Junker, 1969
	1000	GC-EC	0-5 ppb	<0.07 ppb	Southern Idaho, serum	Watson, Benson, and Gabica, 1970
	202	GC-EC	0-2 ppb	0.1 ppb	White males and females, serum	Wyllie, Gabica, and Benson, 1972
Bone	30	GC-EC	NG	0.02 ppm	Fat basis, marrow	Casarett et al., 1968
Brain	32	GC-EC	NG	<0.01	Fat basis	Casarett et al., 1968
	332	GC-EC	NG	0.0 to 0.01 ± 0.01 ppm	Autopsies, brain disease	Radomski et al., 1968
Gonad	36	GC-EC	NG	0.01 ppm	Fat basis	Casarett et al., 1968
Heart	10	GC	0.30-1.56 ppm	0.80 ± 0.30 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969
Kidney	38	GC-EC	NG	0.01 ppm	Fat basis	Casarett et al., 1968
	10	GC	0.19-1.14 ppm	0.70 ± 0.28 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969
Liver	42	GC-EC	NG	0.08 ppm	Fat basis	Casarett et al., 1968
	10	GC	0.03-1.67 ppm	0.68 ± 0.50 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969

Table 41. Heptachlorepoxide (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	332	GC-EC	NG	Trace to 0.05 ± 0.09 ppm	Autopsies, liver disease	Radomski et al., 1968
Lung	25	GC-EC	NG	0.02 ppm	Fat basis	Casarett et al., 1968
	10	GC	0.08-0.31 ppm	0.17 ± 0.07 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969
Lymph	11	GC-EC	NG	<0.01 ppm	Fat basis, tracheobronchial nodes	Casarett et al., 1968
Milk	10	GC-EC	<0.0001-0.0044 ppm	NG	Lactating women	Curley and Kimbrough, 1969
	2 of 28	GC	1.0-1.8 ppb	NG	Lactating women	Dyment et al., 1971
	40	GC	Trace to 5 ppb	0.4 ppb	Women, fat basis, rural Colorado	Savage et al., 1973
	1436	GC-EC	15.24-2050 ppb	91.36 ppb	National study, fat basis	Savage, 1976
	57	GC-EC, GC/MS	Trace to 0.03 ppm	0.004 ppm (trace = 0)	Selected areas of Mississippi and Arkansas, 1973-1974, 27% blacks, whole-milk basis	Strassman and Kutz, 1977
Placenta	53	GC-EC	0.1-6.5 ppb	1.21 ppb	Mother-infant pairs	Selby, Newell, Hauser, and Junker, 1969
Spleen	27	GC-EC	NG	<0.01 ppm	Fat basis	Casarett et al., 1968
	10	GC	0.10-0.52 ppm	0.35 ± 0.08 ppm	Stillbirths	Curley, Copeland, and Kimbrough, 1969
Urine	10	GC	<0.0001-0.0009 ppm	NG	Women slightly higher than men	Cueto and Biros, 1967

Table 42. Hexachlorobenzene — C_6Cl_6

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	86	GC-EC	0-23 ppb	3.6 ppb	Persons living and working near waste-disposal sites:	Burns and Miller, 1975
				4.71 ppb	males	
				2.79 ppb	females	
Milk	663 of 1436	GC-EC	<1-1444.4 ppb	77.7 ppb	National milk survey	Savage et al., 1976

Table 43. Hexachlorophene

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	20	GC-EC	0-80 ppb	20.0 ppb	General population	Shafik, 1973
Milk	12	GC-EC	Trace to 9.0 ppb (1971) 0-8.3 ppb (1973)	5.7 ppb NG	White, urban, middle-class mothers	West, Wilson, and Schaffner, 1975

Table 44. Holmium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00-0.41 ppm	NG	Healthy men, mean age 35.3 years, serum	Gofman et al., 1964

Table 45. Indium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00-0.21 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964

Table 46. Iodine

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00-0.57 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964
Hair	2	MS, AAS	0.03-0.14 µg/g dry wt	NG	Methodology	Yurachek, Clemena, and Harrison, 1969
Milk	5	R	0.03-28%	25% (median)	Percent of administered dose sequestered after 48 hr	Weaver, Kamm, and Dooson, 1960
Teeth	56	MS	0.01-0.07 µg/g dry wt	0.036 µg/g dry wt	Subjects less than 20 years old	Losee, Cutress, and Brown, 1973
Thyroid	5	R	20-39%	25% (median)	Percent of administered dose sequestered after 48 hr	Weaver, Kamm, and Dobson, 1960
Urine	5	R	50-74%	53% (median)	Percent of administered dose sequestered after 48 hr	Weaver, Kamm, and Dobson, 1960

Table 47. Iridium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00-0.13 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964

Table 48. Kepone

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Various	186	NG	<1-1.32 ppm	0.38 ppm	Samples taken from sites treated with mirex during the past ten years	Anonymous, 1976

Table 49. Lanthanum

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00-0.21 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964
Teeth	56	MS	0.02-0.12 ng/g dry wt	0.004 ng/g dry wt	Subjects less than 20 years old, enamel	Losee, Cutress, and Brown, 1973

Table 50. Lead

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	43	C	NG	0.04 ± 0.01 ppm wet wt	Cincinnati area white males, 20-84 years old	Gross et al., 1975
	258	ES	0.1-1.5 mg (total tissue)	0.60 mg		Schroeder and Tipton, 1968
Adrenal	41	C	NG	0.25 ± 0.12 ppm wet wt	Cincinnati area white males, 20-84 years old	Gross et al., 1975
	15	ES	11-140 µg/g ash	27 µg/g ash		Tipton and Cook, 1963
Aorta	45	C	NG	1.65 ± ppm wet wt	Cincinnati area white males, 20-84 years old	Gross et al., 1975
	18	AAS	0.6-7.6 ppm wet wt	3.5 ppm wet wt	Sudden deaths, Baltimore, Maryland	Poklis, 1975
	258	ES	0.15-1.0 mg (total aorta)	0.22 mg		Schroeder and Tipton, 1968
	104	ES	34-280 µg/g ash	140 µg/g ash		Tipton and Cook, 1963
Bladder	2	ES	NG	6 ppm wet wt	Sudden accident victims	Koch et al., 1956
	99 of 112	ES	<5-41 µg/g ash	13 µg/g ash		Tipton and Cook, 1963
Blood	2269	ASV	NG	+40 µg/100 ml	Urban area children	Anderson and Clark, 1974
	70	AAS	13.1-27.4 µg/percent (range of means)	20 µg%	Omaha, Nebraska, area children, half Caucasian and half Negro	Angle, McIntire, and Colucci, 1974
	104	AAS	5.6-27.4 µg/100 ml 4.5-7.2 µg/100 ml 14.5-41.8 µg/100 ml	NG NG NG	Children, 10-18 years old: blood plasma red blood cells	Angle and McIntire, 1974
	1559	E	NG	29.1 µg/100 ml 28.1 µg/100 ml 20.0 µg/100 ml <20.0 µg/100 ml	Philadelphia, Pennsylvania: 1- to 3-year-old children 6-year-old children 10-year-old children 11- to 18-year-old children	Adebonojo, 1974
	258	AAS	NG	16.56 µg/100 ml (mean) 15.8 µg/100 ml (median)	Children in nonsmelter towns	Baker et al., 1977
	158	AAS	NG	16.34 µg/100 ml (mean) 15.2 µg/100 ml (median)	Children in lead smelter towns	
	909	AAS	NG	16.36 µg/100 ml (mean) 15.4 µg/100 ml (median)	Children in copper smelter towns	
	347	AAS	NG	21.04 µg/100 ml (mean) 18.3 µg/100 ml (median)	Children in zinc smelter towns	

Table 50. Lead (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	34	AAS	<80 µg/100 ml	27-33 µg/100 ml	Pistol range instructors from Georgia	Landrigan, McKinney, Hopkins, Rhodes, Price, and Cox, 1975
	450	AAS	14-210 µg%	40.8 µg%	Children	Rosen, 1972
	26	AAS	11-78 µg%	33.8 µg%	Children	Rosen, 1972
	119	AAS	2-81 µg/100 ml	26.2 µg/100 ml	Illinois children	Thomas, Rising, and Moore, 1976
	379	AAS	9-102 µg/100 ml	40 µg/100 ml	Newark, New Jersey, 1- to 8-year-old children	Baglan et al., 1974
	84	AAS	NG	0.91 ± 0.77 µg/g	Maternal blood from Nashville, Tennessee, hospitals	Baglan et al., 1974
	130	AAS	NG	0.58 ± 0.93 µg/g	Fetal blood from Nashville, Tennessee, hospitals	Baglan et al., 1974
	122	ES	NG	0.0039 ± 0.0002 mg/100 ml	Los Angeles area blood donors, serum	Butt et al., 1964
	96	ES	NG	0.0027 ± 0.0005 mg/100 ml	Los Angeles area surgical patients, serum	Butt et al., 1964
	48	ES	NG	0.0028 ± 0.0008 mg/100 ml	Los Angeles area residents, serum	Butt et al., 1964
	47	ES	NG	0.0177 ± 0.0008 mg/100 ml	Los Angeles area residents	Butt et al., 1964
	5226	AAS	40-60 µg/100 ml	50 µg/100 ml	Newark, New Jersey, 1- to 15-year-old children	Caprio, Margulis, and Joselow, 1974
	75	AAS	19-81 µg/100 ml	40.7 µg/100 ml	Charleston, South Carolina, preschool children, 36-42% hematocrit levels	Chisolm et al., 1974
	40	AAS	19-71 µg/100 ml	36.9 µg/100 ml	Charleston, South Carolina, preschool children, 30-35% hematocrit levels	Chisolm et al., 1974
	18	AAS	33-68 µg/100 ml	NG	Children 13-67 months of age	Chisolm et al., 1975
	230	AAS	3-70 µg/100 ml	21 µg/100 ml	Rural children	Cohen, Bowers, and Lepow, 1973
	272	AAS	6-136 µg/100 ml	30 µg/100 ml	Urban children	Cohen, Bowers, and Lepow, 1973
	34	AAS	7-80 µg/100 ml	25.4 ± 17 µg/100 ml	Autistic and atypical children	Cohen, Johnson, and Caparulo, 1976

Table 50. Lead (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	10	AAS	9-22 µg/100 ml	15.2 ± 4.2 µg/100 ml	Normal children	Cohen, Bowers, and Lepow, 1976
	8	AAS	NG	41.1 ± 12.2 µg/100 ml	Hyperactive children with history of lead poisoning	David, 1974
	37			22.2 ± 10 µg/100 ml	Nonhyperactive children	
	119	AAS	5-64.5 µg/100 ml	NG	Hyperactive and nonhyperactive children	David, Clark, and Voeller, 1972
	54		5-54.5 µg/100 ml	26 µg/100 ml	Hyperactive	
	8		25-64.5 µg/100 ml	41 µg/100 ml	Hyperactive with history of lead poisoning	
	37		5-44.5 µg/100 ml	22 µg/100 ml	Nonhyperactive	
	68	NG	1-53 µg/100 ml	30 µg/100 ml	Exposed urban children, mostly Negro, 60% female	de la Burdé and Shapiro, 1975
	1	NG	NG	156 µg/100 ml	Caucasian female	Dickinson et al., 1972
	1	NG	NG	88 µg/100 ml	Male	
	3	NG	NG	14 µg/100 ml	Children	
	249	NG	4.3-120 µg/100 ml	NG	Fetal blood from controls	Fahim, Fahim, and Hall, 1976
	253	NG	4.6-17.5 µg/100 ml	NG	Fetal blood from patients living in lead mining region	
	249	NG	13.1-30.1 µg/100 ml	NG	Maternal blood from controls	Fahim, Fahim, and Hall, 1976
	253	NG	14.3-29.1 µg/100 ml	NG	Maternal blood from patients living in lead mining region	
	12	AAS	12-60 µg/100 ml	NG	Nine children, three adults	Fung et al., 1975
	381	AAS	10.0-12.6 µg/100 ml (mean range)	10.5 µg/100 ml	Maternal blood, Louisiana patients 11 to >35 years old	Gershanik, Brooks, and Little, 1974
	218	AAS	7.0-11.1 µg/100 ml (mean range)	9.4 µg/100 ml	Cord blood, Louisiana patients 11 to >35 years old	Gershanik, Brooks, and Little, 1974
	39	XRS	0.07-0.53 ppm	NG	Healthy males, mean age 35.3 years	Gofman et al., 1964
	105	C	0-100 µg/100 ml	21 µg/100 ml	New York City residents	Goldwater and Hoover, 1967
	33	C	10-27 µg/100 ml	21 µg/100 ml	California residents	
	40	C	10-53 µg/100 ml	16 µg/100 ml	Ohio residents	
	385	AAS	<10-100+ µg%	NG	Kansas City children 1-3 years old	Green, Wise, and Small, 1973
	43	C	NG	0.21 ± 0.09 ppm wet wt	Cincinnati area, white males, 20-84 years old	Gross et al., 1975

Table 50. Lead (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	>84,000	AAS	10-110 µg/100 ml	NG	New York City children of lower socioeconomic status	Guinee, 1972
	116	AAS	9.4-20.9 µg/100 ml	NG	School-aged males	Hammer, Finklea, Hendricks, Hinners, Riggan, and Shy, 1971
	1877	NG	NG	0.011-0.038 mg/100 g	Males from U.S. major cities	Harmond, 1969
	700	NG	NG	0.011-0.026 mg/100 g	Philadelphia residents	Hammond, 1969
		C			New Haven, Connecticut, patients, maternal venous blood:	Harris and Holley, 1972
	11		10-20 µg/100 g	14.0 µg/100 g	suburban	
	13		10-20 µg/100 g	12.5 µg/100 g	urban ghetto	
	24		10-20 µg/100 g	13.2 µg/100 g	total sample	
		C			New Haven, Connecticut, patients, cord blood:	Harris and Holley, 1972
	11		10-20 µg/100 g	12.7 µg/100 g	suburban	
	13		10-20 µg/100 g	11.9 µg/100 g	urban ghetto	
	24		10-20 µg/100 g	12.3 µg/100 g	total sample	
	100	ASV	<1-81 µg/100 ml	14.6 µg/100 ml	Ann Arbor, Michigan, residents, 18-58 years old	Hecker et al., 1974
	897	C	0.001-0.060 mg/100 g	NG	Urban and rural area residents	Hofreuter et al., 1961
	59	AAS	111-295 µg/liter	160 µg/liter	Men	Hohnadel et al., 1973
			76-142 µg/liter	96 µg/liter	Women	
			78-159 µg/liter	114 µg/liter	Women using oral contraceptives	
	252	AAS	NG	16.4 0.7 µg/100 ml	Los Angeles	Johnson et al., 1975a
			NG	10.5 0.4 µg/100 ml	Lancaster	
	NG	ES	NG	0.025 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	NG	ES	0.7-7.7 µg/100 ml	3.9 µg/100 ml	Sudden accident victims, plasma	Koch et al., 1956
	243	AAS	<1-109.27 µg/100 ml	13.17 µg/100 ml	19 cities	Kubota, Lazar, and Losee, 1968
	47	AAS			47 matched pairs:	Kuhnert, Erhard, and Kuhnert, 1977
			0.024-0.072 µg/10^9 RBC	0.044 µg/10^9 RBC	maternal blood	
			0.021-0.076 µg/10^9 RBC	0.037 µg/10^9 RBC	fetal blood	

Table 50. Lead (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	1369	NG	40-68 µg/100 ml	48 µg/100 ml	Children, >40 mg/100 ml found in 53% of cases living within 1.6 km of smelter	Landrigan, Gehlbach, Rosenblum, Shoults, Candelaria, Barthel, Liddle, Smrek, Staehling, and Sanders, 1975
	1	C	12-28 µg/100 g	18.37 µg/100 g	35 samples	Lerner, 1975
	10	MS	NG	7.2-21.7 µg/100 g	Age, 25-37 years	Manton, 1977
	4000+	C	NG	17.3 ± 6.4 to 19.9 ± 8.1 µg/100 ml	DuPont employees from 23 locations	McLaughlin, Linch, and Snee, 1973
	5750	C	15.5-21.6 µg/100 g (geometric mean)	23.3 µg/100 g	DuPont employees from 23 locations	McLaughlin, Linch, and Snee, 1973
	46	C	10-25 µg/100 ml 50-80 µg/100 ml	20.4 µg/100 ml 56.9 µg/100 ml	125 controls 21 subjects, chosen from low income	Mooty, Ferrand, and Harris, 1975
	343	AAS	NG	0.37 ± 0.15 µg/g	Children	Pueschel, Kopito, and Schwachman, 1972
	5	MS	0.17-0.25 µg/g	0.194 µg/g	Healthy adult males	Rabinowitz, Wetherill, and Kopple, 1975
	19	AAS	14-30 µg/100 ml 41-51 µg/100 ml	22.6 µg/100 ml 45.3 µg/100 ml	Black children, age 4-6 years Effect on immune exposure	Reigart and Graber, 1976
	NG	NG	NG	0.29 µg/ml	Normal level	Rentoul and Smith, 1973
	100	NG	NG NG	0.03 mg/100 ml 0.027 mg/100 ml	New York: 50 poisoned children 50 controls	Russo et al., 1973
	1812	NG	10-200 µg/100 ml	20.8-43.9 µg/100 ml	Three neighborhoods in Chicago, summer, from paint	Sachs, 1974
	28	C	NG	24.2 µg/100 ml 22.0 µg/100 ml 21.5 µg/100 ml 15.2 µg/100 ml	Urban smokers Urban nonsmokers Suburban smokers Suburban nonsmokers	Scanlon, 1971
	258	ES	0.22-2.7 mg (total blood)	1.4 mg	Total in blood	Schroeder and Tipton, 1968
	24	AAS, ASV	12-77 µg/100 ml	NG	Methodology	Searle, Chan, and Davidow, 1973
	NG	ASV	59-68 µg/100 ml	NG	Effect on catecholamines	Silbergeld and Chisolm, 1976

Table 50. Lead (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	320	AAS	4-86 µg/100 ml	36 µg/100 ml	Children, ages 1-5 years	Singh, Bogden, and Joselow, 1975
	1 of 79 3 of 190	AAS	>40 µg/100 ml	NG	Children: 1972 1974	Smith, Nelson, and Stewart, 1976
	60	AAS	0.87-30.5 µg/100 g	15.7 µg/100 g	White middle and upper class, Salt Lake City	Smith, Temple, and Reading, 1976
	124	AAS	NG	23 ± 1.0 to 84 ± 5.0 µg/100 ml	Blacks and Puerto Ricans, Bronx, age 1-6 years	Sorrell, Rosen, and Roginsky, 1977
	100	C	13.5-34.6 µg/100 g 3.8-43.0 µg/100 g	NG	Live near freeway Do not live near freeway	Thomas et al., 1967
Bone		C				
	45		NG	14.09 ± 11.22 ppm wet wt	Cincinnati area white males, 20-84 years old: tibia	Gross et al., 1975
	44		NG	13.81 ± 9.09 ppm wet wt	skull	
	45		NG	7.14 ± 4.19 ppm wet wt	rib	
	44		NG	4.42 ± 2.52 ppm wet wt	vertebrae	
	120	AAS	11-214 ppm ash wt	59 ppm ash wt	North and South Carolina adult and pediatric autopsies	Hammer et al., 1973
	14	AAS	0.2-32 ppm ash wt	NG	North and South Carolina pediatric autopsies	Hammer et al., 1973
	15	ES, Ch	0.21-1.11 mg/100 g	0.65 mg/100 mg	Autopsies, flat bone	Kehoe, 1961
	15	ES, Ch	0.67-3.59 mg/100 g	1.78 mg/100 mg	Autopsies, long bone	Kehoe, 1961
	NG	ES	NG	1.88 mg/100 g wet wt	Long bone	Kehoe, Cholak, and Story, 1940
	NG	ES	NG	0.470 mg/100 g	Rib bone	Kehoe, Cholak, and Story, 1940
	2	ES	NG	19 ppm		Koch et al., 1956
	258	ES	7.5-195 mg (total tissue)	110.0 mg	Total in bone	Schroeder and Tipton, 1968
	40	AAS	77-237 µg/g ash	NG	One skeleton	Strehlow and Kneip, 1969
Brain		C				
	39		NG	0.11 ± 0.05 ppm wet wt	Cincinnati area white males, 20-84 years old: grey matter	Gross et al., 1975
	41		NG	0.11 ± 0.04 ppm wet wt	white matter	

Table 50. Lead (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	15	ES	0.01-0.09 mg/100 g wet wt	0.04 mg/100 g wet wt	Autopsies	Kehoe, 1961
	NG	ES	NG	0.013 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	3	ES	NG	0.2 ppm wet wt		Koch et al., 1956
	NG	ES	NG	0.08 ± 0.01 mg/100 g dry wt	Above 1 year old	Nusbaum et al., 1958
	NG	NG	NG	0.20 µg/g dry wt	Normal levels	Rentoul and Smith, 1973
	258	ES	0-8.8 mg (total brain)	0.14 mg	Total in brain	Schroeder and Tipton, 1968
	89 of 129	ES	<5-39 µg/g ash	5 µg/g ash		Tipton and Cook, 1963
Connective	258	ES	0-4.8 mg (total tissue)	1.08 mg	Total in connective tissue	Schroeder and Tipton, 1968
Diaphragm	75 of 91	ES	<5-29 µg/g ash	10 µg/g ash		Tipton and Cook, 1963
Esophagus	55 of 68	ES	<5-70 µg/g ash	10 µg/g ash		Tipton and Cook, 1963
Fascia	43	C	NG	0.10 ± 0.05 ppm wet wt	Cincinnati area white males, 20-84 years old	Gross et al., 1975
Feces	248	AAS	NG NG	0.90 ± 0.09 µg/g 1.22 ± 0.08 µg/g	Before auto catalysts: Los Angeles Lancaster	Johnson et al., 1975a
	117	ES	NG	0.336 mg/24 hr	Urban	Kehoe et al., 1940
Fetal membranes	249 253	NG NG	9-40 µg/100 g 11-12 µg/100 g	NG NG	Control patients Patients living in a lead mining region	Fahim, Fahim, and Hall, 1976
Gastrointestinal tract	258	ES	0-3.1 mg (total organ)	0.15 mg	Total in gastrointestinal tract	Schroeder and Tipton, 1968
Hair	160	AAS	NG	12.95 µg/g (mean) 10.1 µg/g (median)	Children in nonsmelter towns	Baker et al., 1977
	126	AAS	NG	77.29 µg/g (mean) 49.3 µg/g (median)	Children in lead smelter towns	
	872	AAS	NG	22.03 µg/g (mean) 18.0 µg/g (median)	Children in copper smelter towns	
	294	AAS	NG	41.75 µg/g (mean) 30.7 µg/g (median)	Children in zinc smelter towns	

Table 50. Lead (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	50	AAS	NG	31.5 µg/g	Maternal scalp hair, Cincinnati hospital patients, mean age 22.5 years	Baumslag et al., 1974
	51	AAS	NG	16.6 µg/g	Maternal pubic hair, Cincinnati hospital patients, mean age 22.5 years	Baumslag et al., 1974
	34	AAS	NG	13.9 µg/g	Neonatal scalp hair, Cincinnati hospital patients	Baumslag et al., 1974
		AAS	2.12-100.00 µg/g			Creason et al., 1975
	284			13.47 µg/g	Children: New York City	
	126			11.74 µg/g	Riverhead	
	96			14.07 µg/g	Queens	
	71			17.13 µg/g	Bronx	
		AAS	1.96-155.00 µg/g			Creason et al., 1975
	207			12.21 µg/g	Adults: New York City	
	85			10.39 µg/g	Riverhead	
	77			14.50 µg/g	Queens	
	49			12.88 µg/g	Bronx	
	25	AAS	7.6-61 ppm	24.1 ppm	Females, 13-72 years old	Eads and Lambdin, 1973
	25	AAS	10.6-50 ppm	26.7 ppm	Males, 9-60 years old	
	18	ES	0.0041-0.01% dry tissue	NG	White males, 15-70 years old	Goldblum, Derby, and Lerner, 1953
	116	AAS	6.5-45.9 ppm	NG	Scalp hair from school-aged males	Hammer, Finklea, Hendricks, Hinners, Riggan, and Shy, 1971
		AAS				Hammer, Finklea, Hendricks, Shy, and Horton, 1971
	45		0-595 ppm	107.1 ppm	Fourth-grade males: lead and zinc mining and smelting area	
	25		0-195 ppm	44.3 ppm	lead and zinc smelting area	
	37		0-85 ppm	14.3 ppm	copper smelting area	
	21		0-85 ppm	12.1 ppm	government and commercial area	
	38		0-25 ppm	7.6 ppm	education and farm trading area	
	12	AAS	2-141 µg/g	34 µg/g	Scalp hair	Hinners et al., 1974
	230	AAS	NG	44.9 ± 4.3 µg/g	Long hair, Los Angeles	Johnson et al., 1975a
	230	AAS	NG	19.3 ± 3.1 µg/g	Long hair, Lancaster	
	188	AAS	NG	56.2 ± 7.0 µg/g	Short hair, Los Angeles	
	188	AAS	NG	15.7 ± 1.3 µg/g	Short hair, Lancaster	

Table 50. Lead (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	705	AAS	NG	118 ± 100 µg/g 27 µg/g	Age 6 months to 6 years, impoverished section of Boston: study area controls	Pueschel, Kopito, and Schwachman, 1972
	NG	NG	NG	35 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	180	AAS	NG	17.8 ± 2.2 µg/g 19 ± 3 µg/g	117 women 47 men	Schroeder and Nason, 1969
	258	ES	0.05-1.5 mg (total tissue)	0.75 mg	Total in hair	Schroeder and Tipton, 1968
	1	AAS	NG	44.7 ± 0.3 µg/g	Analytical	Sorenson et al., 1973
	260	NG	1-2080 µg/g	17.6-28.8 µg/g	Traffic and desk officers, Boston, Irish and Italian	Speizer and Ferris, 1973
	2	MS, AAS	NG	14.5 and 21.8 µg/g dry wt	Analytical	Yurachek, Clemena, and Harrison, 1969
Heart	43	C	NG	0.08 ± 0.04 ppm wet wt	Cincinnati area white males, 20-84 years old	Gross et al., 1975
	15	ES, Ch	NG	0.04 mg/100 g wet wt	Autopsies	Kehoe, 1961
	NG	ES	NG	0.038 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	NG	ES	NG	0.20 ± 0.01 mg/100 g dry wt	Above 1 year old	Nusbaum et al., 1958
	258	ES	0-0.4 mg (total organ)	0.02 mg	Total in heart	Schroeder and Tipton, 1968
	79 of 140	ES	<5-18 µg/g ash	5 µg/g ash		Tipton and Cook, 1963
Intestine	45	C	NG	0.12 ± 0.05 ppm wet wt	Cincinnati area white males, 20-84 years old, jejunum	Gross et al., 1975
	45	C	NG	0.07 ± 0.03 ppm wet wt	Cincinnati area white males, 20-84 years old, cecum	Gross et al., 1975
	NG	ES	NG	0.023 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
Large intestine	1	ES	NG	0.3 ppm wet wt		Koch et al., 1956
Small intestine	7	ES	NG	0.8 ppm wet wt		Koch et al., 1956

Table 50. Lead (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Duodenum	67 of 68	ES	5-82 µg/g ash	25 µg/g ash (median)		Tipton and Cook, 1963
Jejunum	97 of 104	ES	5-53 µg/g ash	13 µg/g ash (median)		Tipton and Cook, 1963
Ileum	82 of 84	ES	5-62 µg/g ash	20 µg/g ash (median)		Tipton and Cook, 1963
Cecum	31	ES	5-90 µg/g ash	27 µg/g ash (median)		Tipton and Cook, 1963
Sigmoid colon	94 of 109	ES	<5-50 µg/g ash	13 µg/g ash (median)		Tipton and Cook, 1963
Rectum	41 of 42	ES	5-77 µg/g ash	20 µg/g ash (median)		Tipton and Cook, 1963
Kidney		C				
	45		NG	0.79 ± 0.42 ppm wet wt	Cincinnati area white males, 20-84 years old: cortex	Gross et al., 1975
	44		NG	0.48 ± 0.22 ppm wet wt	medulla	
	120	AAS	15-246 ppm ash wt	30 ppm ash wt	North and South Carolina adult and pediatric autopsies	Hammer et al., 1973
	14	AAS	1.4-74 ppm ash wt	NG	North and South Carolina pediatric autopsies	Hammer et al., 1973
		AAS			St. Louis area veteran autopsies:	Hirst et al., 1973
	12		NG	120 µg/g ash	controls	
	12		NG	120 µg/g ash	emphysema patients	
	15	ES, Ch	0.015-0.16 mg/100 g wet wt	0.05 mg/100 g wet wt	Autopsies	Kehoe, 1961
	NG	ES	NG	0.027 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	6	ES	1.3-48.7 µg/g dry wt	17.7 µg/g dry wt	Normals	Koch, Smith, and McNelly, 1957
	80	AAS	NG	49 µg/g ash	Controls	Morgan, 1969
				60 µg/g ash	Hypertensives	
				47 µg/g ash	Heart disease	
				50 µg/g ash	Malignant diseases	
	100	AAS	16-1728 µg/g ash	69 µg/g ash	Autopsies, VA hospital, Birmingham, Alabama	Morgan, 1972*b*
	46	AAS	34-68 µg/g ash	54 µg/g ash	Necropsies, VA hospital, Birmingham, Alabama	Morgan, 1972*c*
	NG	ES	NG	0.36 ± 0.02 mg/100 g dry wt	Above 1 year old	Nusbaum et al., 1958

Table 50. Lead (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	24	AAS	NG	0.166 mg/g ash 123 mg/g ash	12 emphysematous 12 controls	Perry et al., 1972
	150	ES	0.21-1.1 micromoles/g ash	NG	Adults	Perry et al., 1962
	22	AAS	0.40-3.8 ppm wet wt	1.8 ppm wet wt	Sudden deaths, Baltimore, Maryland	Poklis and Freimuth, 1976
	NG	NG	NG	0.27 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	258	ES	0.003-2.0 mg (total organs)	0.34 mg	Total in kidney	Schroeder and Tipton, 1963
	NG	NG	0-1.5+ mg/100 g dry wt	NG	Cancer patients and autopsy specimens	Tietz, Hirsch, and Neyman, 1957
	145	ES	42-220 µg/g ash	98 µg/g ash (median)		Tipton and Cook, 1963
Larynx	50	ES	11-140 µg/g ash	64 µg/g ash (median)		Tipton and Cook, 1963
Liver	45	C	NG	0.98 ± 0.53 ppm wet wt	Cincinnati area white males, 20-84 years old	Gross et al., 1975
	120	AAS	15-785 ppm ash wt	45 ppm ash wt	North and South Carolina adults and pediatric autopsies	Hammer et al., 1973
	14	AAS	0.7-167 ppm ash wt	NG	North and South Carolina pediatric autopsies	Hammer et al., 1973
	12 12		NG NG	120 µg/g ash 140 µg/g ash	St. Louis area veteran autopsies: control emphysema patients	Hirst et al., 1973
	15	ES, Ch	0.04-0.28 mg/100 g wet wt	0.12 mg/100 g wet wt	Autopsies	Kehoe, 1961
	NG	ES	NG	0.130 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	5	ES	4.2-26.0 µg/g dry wt	12.1 µg/g dry wt	Normals	Koch, Smith, and McNelly, 1957
	8	ES	NG	3.8 ppm wet wt	Sudden accident victims	Koch et al., 1956
	NG	ES	NG	0.52 ± 0.02 mg/100 g dry wt	Above 1 year old	Nusbaum et al., 1958
	24	AAS	NG	0.141 mg/g ash 0.111 mg/g ash	12 emphysematous 12 controls	Perry et al., 1972

Table 50. Lead (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	150	ES	0.29–1.2 micromoles/g ash	NG	Adults	Perry et al., 1962
	10	ES	NG	276 ± 176 µg/g ash	Accident victims, St. Louis area	Perry et al., 1973
	22	AAS	1.0–6.3 ppm wet wt	2.5 ppm wet wt	Sudden deaths, Baltimore, Maryland	Poklis and Freimuth, 1976
	NG	NG	NG	1.7 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	258	ES	0.72–13.5 mg (total organ)	3.1 mg	Total in liver	Schroeder and Tipton, 1968
	NG	NG	0–1.3+ mg/100 g dry wt	NG	Cancer patients and autopsy specimens	Tietz, Hirsch, and Neyman, 1957
	150	ES	60–250 µg/g ash	130 µg/g ash (median)		Tipton and Cook, 1963
Lung	42	C	NG	0.36 ± 0.12 ppm wet wt	Cincinnati area white males, 20–84 years old	Gross et al., 1975
		AAS			St. Louis area veteran autopsies:	Hirst et al., 1973
	12		NG	130 µg/g ash	control	
	12		NG	240 µg/g ash	emphysema patients	
	15	ES, Ch	NG	0.02 mg/100 g wet wt	Autopsies	Kehoe, 1961
	NG	ES	NG	0.028 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	4	ES	4.7–21.9 µg/g dry wt	10.6 µg/g dry wt	Normals	Koch, Smith, and McNelly, 1957
	4	ES	NG	1.6 ppm wet wt	Sudden accident victims	Koch et al., 1956
	NG	ES	NG	0.23 ± 0.02 mg/100 g dry wt	Above 1 year old	Nusbaum et al., 1958
	24	AAS	NG	0.210 mg/g ash 0.145 mg/g ash	12 emphysematous 12 controls	Perry et al., 1972
	150	ES	0.062–0.68 micromole/g ash	NG	Adults	Perry et al., 1962
	22	AAS	0.21–1.8 ppm wet wt	0.85 ppm wet wt	Sudden deaths, Baltimore, Maryland	Poklis and Freimuth, 1976
	168	NG	NG	Max — 5500, min — 50, retained 1 year — 0 µg/year	58 cities and 29 nonurban areas	Schroeder, 1970*b*

Table 50. Lead (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	258	ES	0.05–6.1 mg (total organs)	0.39 mg	Total in lung	Schroeder and Tipton, 1963
	66	AAS	NG	0.57–1.67 µg/g	0.57 µg/g females 1.04 µg/g males	Stringer et al., 1974
	NG	NG	0–1.0 mg/100 g dry wt	NG	Cancer patients and autopsy specimens	Tietz, Hirsch, and Neyman, 1957
	141	ES	5–550 µg/g ash	67 µg/g ash (median)	Autopsies, nine cities	Tipton and Shafer, 1964
	141	ES	15–140 µg/g ash	47 µg/g ash (median)		Tipton and Cook, 1963
Lymph nodes	41	C	NG	0.86 ± 0.93 ppm wet wt	Cincinnati area white males, 20–84 years old	Gross et al., 1975
Milk	29	AAS	0.006–0.058 µg/ml	0.026 0.011 µg/ml	U.S. residents, 23–28 years old	Dillon, Wilson, and Schaffner, 1974
	14	AAS	0–0.07 µg/ml	0.02 µg/ml		Lamm et al., 1973
	14	AAS	0.0060–0.0202 ppm	0.0109 ppm	Age, 21–37 years	Pinkerton et al., 1972
Muscle	44	C	NG	0.07 ± 0.03 ppm wet wt	Cincinnati area white males, 20–84 years old	Gross et al., 1975
	15	ES, Ch	0.010–0.17 mg/100 g wet wt	0.03 mg/100 g wet wt	Autopsies	Kehoe, 1961
	NG	ES	NG	0.010 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	8	ES	NG	0.4 ppm wet wt	Sudden accident victims	Koch et al., 1956
	258	ES	0–179.2 mg (total tissue)	1.7 mg	Total in muscle	Schroeder and Tipton, 1968
	65 of 136	ES	<5–16 µg/g ash	<5 µg/g ash (median)		Tipton and Cook, 1963
Nails	18	ES	0.0097–0.024% dry tissue	NG	Healthy males, 15–70 years old	Goldblum, Derby, and Lerner, 1953
Omentum	72 of 74	ES	7–220 µg/g ash	30 µg/g ash (median)		Tipton and Cook, 1963
Ovary	12 of 16	ES	<5–27 µg/g ash	13 µg/g ash (median)		Tipton and Cook, 1963
Pancreas	45	C	NG	0.46 ± 0.23 ppm wet wt	Cincinnati area white males, 20–84 years old	Gross et al., 1975
	2	ES	NG	2.0 ppm wet wt	Sudden accident victims	Koch et al., 1956

Table 50. Lead (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	22	AAS	0.49-1.8 ppm wet wt	0.92 ppm wet wt	Sudden deaths, Baltimore, Maryland	Poklis and Freimuth, 1976
	258	ES	0-1.1 mg (total organ)	0.06 mg	Total in pancreas	Schroeder and Tipton, 1968
	138	ES	18-130 µg/g ash	49 µg/g ash (median)		Tipton and Cook, 1963
Placenta	234	AAS	NG	1.83 ± 2.56 µg/g dry wt	Nashville, Tennessee, hospital patients	Baglan et al., 1974
	554	AAS	NG	0.86 ± 0.28 to 3.12 ± 0.92 micromoles/g	Normal term placentas	Dawson et al., 1968
	554	AAS	NG	1.95 ± 1.42 micromoles/g dry wt	Toxemia and premature placentas	Dawson et al., 1969
	249	NG	6-8 µg/100 g	NG	Control patients	Fahim, Fahim, and Hall, 1976
	253	NG	7-9 µg/100 g	NG	Patients living in lead mining district	
	58	NG	NG	0.293 ± 0.025 µg/g wet wt	Southern and southeastern city hospital patients	Karp and Robertson, 1977
Prostate	41	C	NG	0.20 ± 0.22 ppm wet wt	Cincinnati area white males, 20-84 years old	Gross et al., 1975
	4	ES	NG	0.2 ppm wet wt	Sudden accident victims	Koch et al., 1956
	44 of 50	ES	<5-81 µg/g ash	10 µg/g ash (median)		Tipton and Cook, 1963
Saliva	12	AAS	3-23 µg/100 ml	NG	Nine children, three adults	Fung et al., 1975
Skin	18	ES	0.0252-0.134% dry tissue	NG	Healthy males, 15-70 years old	Goldblum, Derby, and Lerner, 1953
	43	C	NG	0.06 ± 0.03 ppm wet wt	White males, 20-84 years old	Gross et al., 1975
	258	ES	0-11.8 mg (total tissue)	1.5 mg	Total in skin	Schroeder and Tipton, 1968
	21 of 22	ES	16-120 µg/g ash	46 µg/g ash (median)		Tipton and Cook, 1963
Spleen	43	C	NG	0.33 ± 0.15 ppm wet wt	Cincinnati area white males, 20-84 years old	Gross et al., 1975
	15	ES, Ch	0.01-0.07 mg/100 g wet wt	0.03 mg/100 g wet wt	Autopsies	Kehoe, 1961
	NG	ES	NG	0.030 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940

Table 50. Lead (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	3	ES	3.4-9.6 µg/g dry wt	6.2 µg/g dry wt	Normals	Koch, Smith, and McNelly, 1957
	3	ES	NG	1.4 ppm wet wt	Sudden accident victims	Koch et al., 1956
	NG	ES	NG	0.28 ± 0.04 mg/100 g dry wt	Above 1 year old	Nusbaum et al., 1958
	258	ES	0-2.2 mg (total organ)	0.06 mg	Total in spleen	Schroeder and Tipton, 1968
	138 of 143	ES	7-90 µg/g ash	27 µg/g ash (median)		Tipton and Cook, 1963
Stomach	45	C	NG	0.10 ± 0.05 ppm wet wt	Cincinnati area white males, 20-84 years old	Gross et al., 1975
	NG	ES	NG	0.022 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	3	ES	NG	1.0 ppm wet wt	Sudden accident victims	Koch et al., 1956
	123 of 131	ES	5-35 µg/g ash	12 µg/g ash (median)		Tipton and Cook, 1963
Sweat	33	AAS	8-184 µg/liter	51 ± 42 µg/liter	Males	Hohnadel et al., 1973
	15	AAS	49-283 µg/liter	118 ± 72 µg/liter	Females	
	11	AAS	28-171 µg/liter	101 ± 49 µg/liter	Females using oral contraceptives	
Teeth	82	ES	0.25-5.75 mg/100 g	1.51 mg/100 g	Cincinnati residents	Altshuller et al., 1962
	35	AAS	200-3550 ppm	1790 ± 960 ppm	Left maxillary central incisor, Cambridge, Massachusetts, 9-15 years old, enamel	Brudevold et al., 1975
	15	AAS	350-2600 ppm	1410 ± 660 ppm	Left maxillary central incisor, Cambridge, Massachusetts, 9-15 years old, enamel	Brudevold et al., 1975
	153	AAS	NG	5.0 ± 5.9 ppm	115 donors from ages 3.5-12 years	Chatman and Wilson, 1975
		NG			Mostly black children, 60% female:	de la Burdé and Shapiro, 1975
	36		50-150 µg/g	140 µg/g	control children	
	32		120-220 µg/g	218 µg/g	exposed urban children	
	324	AAS	NG	5.1-19.9 ppm (geometric mean)	Children in lead paint area	Lockeretz, 1975

Table 50. Lead (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	56	MS	1.0–6.5 µg/g	3.1 ± 0.16 µg/g	Subjects less than 20 years old, wide geographic area	Losee, Cutress, and Brown, 1973
	109	AAS	2–700 ppm 0–80 ppm	15.1 ± 109.0 ppm 11.1 ± 14.8 ppm	69 urban 40 suburban	Needleman, Tuncay, and Shapiro, 1972
	761	NG	NG	198 µg/g 41.7 µg/g	Old housing New housing	Needleman et al., 1974
	760	ASV	30–>400 µg/g	NG	Philadelphia school children	Needleman and Shapiro, 1974
	40	AAS	254–336 µg/g ash	NG	One skeleton	Strehlow and Kneip, 1969
Testis	43	C	NG	0.15 ± 0.09 ppm wet wt	Cincinnati area white males, 20–84 years old	Gross et al., 1975
	1	ES	NG	0.3 ppm wet wt	Sudden accident victims	Koch et al., 1956
	68 of 72	ES	5–27 µg/g ash	12 µg/g ash (median)		Tipton and Cook, 1963
Thyroid	40	C	NG	0.17 ± 0.11 ppm wet wt	Cincinnati area white males, 20–84 years old	Gross et al., 1975
	2	ES	NG	1.0 ppm wet wt	Sudden accident victims	Koch et al., 1956
	20 of 21	ES	5–54 µg/g ash	10 µg/g ash		Tipton and Cook, 1963
Trachea	17	AAS	0.6–8.8 ppm wet wt	3.0 ppm wet wt	Sudden deaths, age 17–74 years, Baltimore, Maryland	Poklis and Freimuth, 1975
	60	ES	15–120 µg/g ash	44 µg/g ash (median)		Tipton and Cook, 1963
Umbilical cord	249	NG	9–11 µg/100 g	NG	Control patients	Fahim, Fahim, and Hall, 1976
	253	NG	11–12 µg/100 g	NG	Patients living in a lead mining region	
Urine	11	ASV, AAS	22–129 µg/24 hr	NG	Children 13–67 months of age	Chisolm, Barrett, and Harrison, 1975
	4	NG	NG	325 ± 167 µg/100 ml	Hyperactive children with history of lead poisoning	David, 1974
	24	NG	NG	77 ± 92 µg/100 ml	Nonhyperactive children after treatment	
	92	NG	0–>241 µg/liter	NG	Hyperactive and nonhyperactive children	David, Clark, and Voeller, 1972
	50	NG	0–>241 µg/liter	146 µg/100 ml	Hyperactive	
	4	NG	161–>241 µg/liter	325 µg/100 ml	Hyperactive with history of lead poisoning	
	24	NG	0–>241 µg/liter	77 µg/100 ml	Nonhyperactive after treatment	

Table 50. Lead (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	1	NG	NG	86 µg/24 hr	Caucasian female	Dickinson et al., 1972
	110	C	0-118 µg/liter	38 µg/liter	New York City residents	Goldwater and Hoover, 1967
	27		15-75 µg/liter	38 µg/liter	California residents	
	40		10-50 µg/liter	31 µg/liter	Ohio residents	
	8	C	NG	0.06 ± 0.11 ppm	Cincinnati area white males, 20-84 years old	Gross et al., 1975
	438	NG	NG	0.009-0.034 mg/100 g	Philadelphia residents	Hammond, 1969
	897	C	0.002-0.081 mg/liter	NG	Urban and rural area residents	Hofreuter et al., 1961
	402	AAS			Before auto catalysts:	Johnson et al., 1975a
			NG	14.3 ± 0.7 µg/liter	Los Angeles, near freeway	
			NG	10.5 ± 1.0 µg/liter	Lancaster, desert area	
	NG	ES	NG	0.027 mg/liter		Kehoe, Cholak, and Story, 1940
	NG	NG	NG	0.023 µg/ml	Normal level	Rentoul and Smith, 1973
	4000+	C	NG	27.1 ± 16.2 to 29.0 ± 13.3 µg/liter	DuPont employees from 23 locations	McLaughlin, Linch, and Snee, 1973
	5750	C	20.1-25.3 µg/liter (geometric means)	23.3 µg/liter (geometric mean)	DuPont employees from 23 locations	McLaughlin, Linch, and Snee, 1973
	32	ES	NG	120 µg/liter	Normals	Perry and Perry, 1959
				110 µg/liter	Females	
				126 µg/liter	Males	
				149 µg/liter	Blacks	
				97.2 µg/liter	Nonblacks	
	10	AAS	0.4-4.7 µg/100 ml	NG		Searle, Chan, and Davidow, 1973
Uterus	20 of 32	ES	<5-29 µg/g ash	5 µg/g ash (median)		Tipton and Cook, 1963

Table 51. Lithium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	260	AAS	NG	0.78 ± 0.01 μeq/liter	Adult residents, Kansas City, Kansas, serum	Bierenbaum et al., 1975
	260	AAS	NG	48 ± 0.01 μeq/liter	Adult residents, Kansas City, Missouri, serum	Bierenbaum et al., 1975
Hair	277	FP	0.009-0.300 μg/g	0.044 μg/g	New York City children, ages 0-15 years	Creason et al., 1975
	206	FP	0.009-0.228 μg/g	0.056 μg/g	New York City adults, ages ≥16 years	Creason et al., 1975
Placenta	58	NG	NG	0.010 ± 0.002 μg/g wet wt	Southern and southeastern city hospital patients	Karp and Robertson, 1977
Teeth	56	MS	<0.1-4.2 μg/g	1.6 ± 0.12 μg/g	Subjects less than 20 years old, enamel	Losee, Cutress, and Brown, 1973
	208	MS	NG	0.35 ± 0.02 ppm	New England residents less than 20 years old with high caries, enamel	Curzon and Losee, 1977
				0.07 ± 0.02 ppm	South Carolina residents less than 20 years old with low caries, enamel	

Table 52. Lutetium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00-0.13 ppm	NG	Healthy males, mean age 35.3 years, serum	Cofman et al., 1964

Table 53. Magnesium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	2	C	0.0060–0.063% wet wt	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
	150	ES	NG	24 ± 0.2 µg/g wet wt	Accidental deaths	Schroeder, Nason, and Tipton, 1969
Adrenal	1	C	NG	60 ppm wet wt	Sudden accident victims	Koch et al., 1956
	10	ES	0.46–1.5 g/100 g ash	0.84 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Alimentary tract	2	C	0.013–0.021% wet wt	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
Aorta	1	C	NG	140 ppm wet wt	Sudden accident victims	Koch et al., 1956
	46	AAS	130–1740 µg/g dry wt	279–919 µg/g dry wt	Autopsies, 5 months to 91 years old, various diseases, Chicago	Marks et al., 1972
	100	ES	230–600 micromoles/g ash	NG	Adults	Perry, 1968
	94	ES	0.94–2.0 g/100 g ash	1.4 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Bladder	2	C	NG	150 ppm wet wt	Sudden accident victims	Koch et al., 1956
	98	ES	0.86–2.3 g/100 g ash	1.4 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Blood	520	AAS	NG	2.03 ± 0.01 mg/liter 1.91 ± 0.01 mg/liter	Half in hard-water and half in soft-water area: Kansas Missouri	Bierenbaum et al., 1975
	150	ES	NG	38 ± 0.4 µg/g wet wt	Accidental deaths	Schroeder, Nason, and Tipton, 1969
Bone	2	C	0.168–0.191% wet wt	NG	One white male (age 60) and one black male (age 48), skeletal bone	Forbes, Mitchell, and Cooper, 1956
	40 81	AAS	2.4–3.2 µg/g dry wt	2.8 ± 0.33 µg/g dry wt	Normals Osteogenic sarcomas	Janes, McCall, and Elveback, 1972
	2	C	NG	140 ppm wet wt	Sudden accident victims	Koch et al., 1956
	150	ES	NG	1100 ± 25.2 µg/g wet wt	Accidental deaths	Schroeder, Nason, and Tipton, 1969
Brain	2	C	NG	140 ppm wet wt	Sudden accident victims	Koch et al., 1956
	100	ES	260–490 micromoles/g ash	NG	Adults	Perry, 1968

Table 53. Magnesium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	150	ES	NG	150 ± 3.4 µg/g wet wt	Accidental deaths	Schroeder, Nason, and Tipton, 1969
	108	ES	0.58-1.2 g/100 g ash	0.90 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Diaphragm	91	ES	1.2-2.5 g/100 g ash	1.7 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Esophagus	2	C	NG	80 ppm wet wt	Sudden accident victims	Koch et al., 1956
	57	ES	1.0-2.0 g/100 g ash	1.4 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Feces	2	FP	NG	170 ± 19 and 200 ± 13 mg/day	Healthy 23- and 24-year-old males, University of Cincinnati	Tipton, Stewart, and Dickson, 1969
Gastrointestinal tract	150	ES	NG	125 ± 9.6 µg/g wet wt	Accidental deaths	Schroeder, Nason, and Tipton, 1969
Hair	18	ES	0.001-0.010% dry wt	NG	Age, 15-70 years, white	Goldblum, Derby, and Lerner, 1953
	12	AAS	15-166 µg/g	67.66 µg/g	Males and females, various ages, diverse geographic areas	Hinners et al., 1974
	180	AAS	NG	49.7 ± 8.6 µg/g 85.7 ± 13.8 µg/g	117 women 47 men	Schroeder and Nason, 1969
	2	MS, AAS	NG	16.4 and 14.5 µg/g dry wt		Yurachek, Clemena, and Harrison, 1969
Heart	2	C	0.0120-0.0168% wet wt	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
	100	ES	430-860 micromoles/g ash	NG	Adults	Perry, 1968
	150	ES	NG	180 ± 5.5 µg/g wet wt	Accidental deaths	Schroeder, Nason, and Tipton, 1969
	122	ES	1.1-2.3 g/100 g ash	1.6 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Intestine	9	C	NG	150 ppm wet wt	Sudden accident victims	Koch et al., 1956
Duodenum	60	ES	0.85-1.7 g/100 g ash	1.3 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Jejunum	83	ES	0.92-2.1 g/100 g ash	1.2 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Ileum	77	ES	1.1-3.8 g/100 g ash	1.8 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Cecum	31	ES	1.6-5.0 g/100 g ash	2.7 g/100 g ash (median)	Adults	Tipton and Cook, 1963

Table 53. Magnesium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Sigmoid colon	88	ES	1.3-4.5 g/100 g ash	2.0 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Rectum	41	ES	1.4-3.7 g/100 g ash	2.3 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Kidney	2	C	0.0169-0.0236% wet wt	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
	5	NG	542.1-2335.2 µg/g dry wt	1404 µg/g dry wt	Normal levels	Koch, Smith, and McNelly, 1957
	6	C	NG	160 ppm	Sudden accident victims	Koch et al., 1956
	100	ES	450-720 micromoles/g ash	NG	Adults	Perry, 1968
	150	ES	360-680 micromoles/g ash	NG	Adults	Perry et al., 1972
	150	ES	NG	129 ± 3.3 µg/g wet wt	Accidental deaths	Schroeder, Nason, and Tipton, 1969
	121	ES	0.88-1.7 g/100 g ash	1.2 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Larynx	49	ES	0.71-1.8 g/100 g ash	1.1 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Liver	2	C	0.0050-0.0081% wet wt	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
	3	NG	610-2046 µg/g dry wt	1332 µg/g dry wt	Normal levels	Koch, Smith, and McNelly, 1957
	7	C	NG	140 ppm wet wt	Sudden accident victims	Koch et al., 1956
	100	ES	390-820 micromoles/g ash	NG	Adults	Perry, 1968
	150	ES	340-750 micromoles/g ash	NG	Adults	Perry et al., 1962
	150	ES	NG	172 ± 5.2 µg/g wet wt	Accidental deaths	Schroeder, Nason, and Tipton, 1969
	126	ES	0.83-1.8 g/100 g ash	1.3 g/100 g ash (median)	Adults	Tipton and Cook, 1963
	12	Ch, ES	NG	128 ± 44.0 ppm wet wt 103 ± 28.0 ppm wet wt	Seven noncirrhotic Five cirrhotic patients	Vallee et al., 1957
Lungs	2	C	0.0047-0.0069% wet wt	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
	3	NG	1123.2-1338.5 µg/g dry wt	1205 µg/g dry wt	Normal levels	Koch, Smith, and McNelly, 1957
	4	C	NG	80 ppm wet wt	Sudden accident victims	Koch et al., 1956
	26	AAS	244-820 µg/g dry wt	517-518 µg/g dry wt	Autopsies, 5 months to 9 years old, various diseases, Chicago area	Marks et al., 1972

Table 53. Magnesium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	100	ES	300-600 micromoles/g ash	NG	Adults	Perry, 1968
	150	ES	260-550 micromoles/g ash	NG	Adults	Perry et al., 1962
	150	ES	NG	71 ± 2.2 µg/g wet wt	Accidental deaths	Schroeder, Nason, and Tipton, 1969
	119	ES	3800-16,000 µg/g ash	9100 µg/g ash	Autopsies, nine cities	Tipton and Shafer, 1964
	119	ES	0.62-1.3 g/100 g ash	0.86 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Muscle	2	C	0.017-0.0198% wet wt	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
	12	C	NG	320 ppm wet wt	Sudden accident victims	Koch et al., 1956
	150	ES	NG	189 ± 7.2 µg/g wet wt	Accidental deaths	Schroeder, Nason, and Tipton, 1969
	119	ES	0.98-2.4 g/100 g ash	1.5 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Myocardium	26	AAS	613-1590 µg/g dry wt	724-1290 µg/g dry wt	Autopsies, 5 months to 91 years old, various diseases, Chicago area	Marks et al., 1972
Nails	18	ES	0.0023-0.011% dry wt	NG	Age, 15-70 years, white	Goldblum, Derby, and Lerner, 1953
Nerve	2	C	0.0097-0.0107% wet wt	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
Omentum	72	ES	0.65-1.9 g/100 g ash	1.2 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Ovary	16	ES	0.70-1.2 g/100 g ash	0.87 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Pancreas	3	C	NG	260 ppm wet wt	Sudden accident victims	Koch et al., 1956
	150	ES	NG	160 ± 4.4 µg/g wet wt	Accidental deaths	Schroeder, Nason, and Tipton, 1969
	114	ES	15-24 g/100 g ash	20 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Placenta	554	AAS	NG	0.98 ± 0.34 micromole/g dry wt	Normal deliveries, Houston, Texas	Dawson et al., 1969
	554	AAS	NG	0.71 ± 0.17 to 1.48 ± 0.25 micromoles/g dry wt		Dawson et al., 1968
Prostate	2	C	NG	300 ppm wet wt	Sudden accident victims	Koch et al., 1956

Table 53. Magnesium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	40	ES	1.1-2.2 g/100 g ash	1.5 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Skin	2	C	0.0048-0.0102% wet wt	NG	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
	18	ES	0.001-0.015% dry wt	NG	Age, 15-70 years, white	Goldblum, Derby, and Lerner, 1953
	150	ES	NG	59 ± 4.0 µg/g wet wt	Accidental deaths	Schroeder, Nason, and Tipton, 1969
	27	AAS	75-112 mg/kg dry wt	NG		Subryan et al., 1975
	19	ES	0.60-1.1 g/100 g ash	0.86 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Spleen	2	C	NG	0.0124% wet wt	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
	5	C	NG	85 ppm wet wt	Sudden accident victims	Koch et al., 1956
	3	NG	595-1208 µg/g dry wt	985 µg/g dry wt	Normal levels	Koch, Smith, and McNelly, 1957
	26	AAS	445-1080 µg/g dry wt	567-716 µg/g dry wt	Autopsies, 5 months to 91 years old, various diseases, Chicago area	Marks et al., 1972
	100	ES	270-590 micromoles/g ash	NG	Adults	Perry, 1968
	150	ES	NG	128 ± 4.2 µg/g wet wt	Accidental deaths	Schroeder, Nason, and Tipton, 1969
	123	ES	0.70-1.5 g/100 g ash	0.92 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Stomach	3	C	NG	320 ppm wet wt	Sudden accident victims	Koch et al., 1956
	110	ES	0.90-2.0 g/100 g ash	1.4 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Teeth	35	AAS	88-5720 ppm	1650 ± 890 ppm	School children in Cambridge, Massachusetts	Brudevold et al., 1975
	2	C	NG	0.618% wet wt	One white male (age 60) and one black male (age 48)	Forbes, Mitchell, and Cooper, 1956
Testis	2	C	NG	150 ppm	Sudden accident victims	Koch et al., 1956
	68	ES	0.78-1.5 g/100 g ash	1.0 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Thyroid	2	C	NG	160 ppm wet wt	Sudden accident victims	Koch et al., 1956
	14	ES	0.23-1.5 g/100 g ash	0.90 g/100 g ash (median)	Adults	Tipton and Cook, 1963

Table 53. Magnesium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Trachea	57	ES	0.71-1.8 g/100 g ash	1.2 g/100 g ash (median)	Adults	Tipton and Cook, 1963
Urine	2	FP	NG	98 ± 5 and 92 ± 4 mg/day	Healthy 23- and 25-year-old males, University of Cincinnati	Tipton, Stewart, and Dickson, 1969
Uterus	30	ES	0.80-1.7 g/100 g ash	1.1 g/100 g ash (median)	Adults	Tipton and Cook, 1963

Table 54. Manganese

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adrenal	13	ES	NG	36 ± 3.1 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	13	ES	24-49 µg/g ash	32 µg/g ash	Adults	Tipton and Cook, 1963
Aorta	100	ES	0.11-0.69 micromole/g ash	NG	Adults	Perry, 1968
	95	ES	NG	11 ± 1.2 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	95	ES	4-17 µg/g ash	8 µg/g ash	Adults	Tipton and Cook, 1963
Bladder	109	ES	NG	18 ± 1.7 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	109	ES	6-40 µg/g ash	13 µg/g ash	Adults	Tipton and Cook, 1963
Blood	266	ES	NG	0.0025 ± 0.0002 mg/100 ml 0.0028 ± 0.0002 mg/100 ml 0.0013 ± 0.0001 mg/100 ml 0.0040 ± 0.0001 mg/100 ml	122 blood donors 96 surgical and degenerative disease patients, serum 48 normals, serum 48 normals, whole blood	Butt et al., 1964
	14	NAA	NG	0.587 ± 0.183 µg/liter 8.44 ± 2.73 µg/liter	Plasma, normals Whole blood, normals	Cotzias, Miller, and Edwards, 1967
	12	C	0.36-0.90 ng/ml	NG	Los Angeles, California, laboratory workers, serum	Fernandez, Sobel, and Jacobs, 1963
	39	XRS	NG	0.00-0.06 ppm	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964
	NG	ES	NG	0.015 mg/100 g		Kehoe, Cholak, and Story, 1940
	NG	NG	NG	0.15 µg/ml		Rentoul and Smith, 1973
Bone	40	AAS	3.5-5.2 µg/g dry wt	4.6 ± 1.62 µg/g dry wt	Normals	Janes, McCall, and Elveback, 1972
	81	AAS	2.4-10.3 µg/g dry wt	6.6 ± 4.37 µg/g dry wt	Osteogenic sarcomas	
	NG	ES	NG	0.300 mg/100 g 0.170 mg/100 g wet wt	Long bone Rib bone	Kehoe, Cholak, and Story, 1940
	91	ES	NG	2 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
Brain	99	ES	NG	0.13 ± 0.01 mg/100 g dry wt	Above 1 year old	Nusbaum et al., 1958
	100	ES	0.26-0.62 micromole/g ash	NG	Adults	Perry, 1968

Table 54. Manganese (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	NG	NG	NG	1.00 µg/g dry wt		Rentoul and Smith, 1973
	127	ES	NG	20 ± 0.7 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	127	ES	10-32 µg/g ash	18 µg/g ash	Adults	Tipton and Cook, 1963
Diaphragm	91	ES	NG	17 ± 1.2 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	91	ES	6-32 µg/g ash	15 µg/g ash	Adults	Tipton and Cook, 1963
Esophagus	66	ES	NG	17 ± 1.5 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	66	ES	6-40 µg/g ash	13 µg/g ash	Adults	Tipton and Cook, 1963
Feces	2	FP	NG	2.5 ± 0.6 mg/day 3.0 ± 0.4 mg/day	Healthy 23- and 25-year-old males, University of Cincinnati	Tipton, Stewart, and Dickson, 1969
Hair	33	NAA	0.08-20 ppm	2.1 ppm	Adults and children, Oak Ridge, Tennessee	Bate and Dyer, 1965
	498	ES			Three New York City communities:	Creason et al., 1975
			0.05-12.0 µg/g 0.07-11.0 µg/g	0.56 µg/g 0.95 µg/g	children adults	
	50	AAS	0.8-3.2 ppm <1-2.2 ppm	NG NG	25 men, age 9-60 years 25 women, age 13-72 years	Eads and Lambdin, 1973
	18	ES	1.0×10^{-9} to 5.5×10^{-12} dry wt	NG	White males, 15-70 years old	Goldblum, Derby, and Lerner, 1953
	12	AAS	0.2-4.0 µg/g	1.4 µg/g	Males and females of various ages and diverse geographic area, scalp hair	Hinners et al., 1974
	13	NAA	NG	1.466 µg/g	Controls	Mahler et al., 1970
	18	NAA	NG	1.062 µg/g	Dialysis patients	
	12	NAA	NG	0.549 µg/g	Uremics	
	NG	NG	NG	2.51 µg/g dry wt		Rentoul and Smith, 1973
	2	AAS	NG	1.7 µg/g dry wt		Yurachek, Clemens, and Harrison, 1969
		MS	NG	1.8 µg/g dry wt		
Heart	NG	ES	NG	0.032 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940

Table 54. Manganese (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	186	ES	NG	0.15 ± 0.01 mg/100 g dry wt	Above 1 year old	Nusbaum et al., 1958
	100	ES	0.27-0.86 micromole/g ash	NG	Adults	Perry, 1968
	NG	NG	NG	0.88 µg/g dry wt		Rentoul and Smith, 1973
	139	ES	NG	23 ± 0.9 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	139	ES	12-40 µg/g ash	20 µg/g ash	Adults	Tipton and Cook, 1963
Intestine	NG	ES	NG	0.035 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
Duodenum	67	ES	NG	70 ± 10.0 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
Jejunum	101	ES	NG	68 ± 3.9 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
Ileum	84	ES	NG	110 ± 11.0 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
Cecum	31	ES	NG	180 ± 31.0 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
Sigmoid colon	107	ES	NG	76 ± 9.7 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
Rectum	42	ES	NG	82 ± 19.0 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
Duodenum	67	ES	25-100 µg/g ash	57 µg/g ash	Adults	Tipton and Cook, 1963
Jejunum	101	ES	32-120 µg/g ash	58 µg/g ash	Adults	Tipton and Cook, 1963
Ileum	84	ES	33-200 µg/g ash	74 µg/g ash	Adults	Tipton and Cook, 1963
Cecum	31	ES	24->400 µg/g ash	110 µg/g ash	Adults	Tipton and Cook, 1963
Sigmoid colon	107	ES	16-150 µg/g ash	46 µg/g ash	Adults	Tipton and Cook, 1963
Rectum	42	ES	11-180 µg/g ash	39 µg/g ash	Adults	Tipton and Cook, 1963
Kidney	NG	ES	NG	0.060 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	316	ES	NG	0.30 ± 0.01 mg/100 g dry wt	Above 1 year old	Nusbaum et al., 1958
	150	ES	0.82-2.7 micromoles/g ash	NG	St. Louis adults who died unexpectedly	Perry et al., 1962

Table 54. Manganese (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	100	ES	0.73-2.0 micromoles/g ash	NG	Adults	Perry, 1968
	NG	NG	NG	3.34 µg/g dry wt		Rentoul and Smith, 1973
	143	ES	NG	91 ± 4.0 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	NG	ES	0-1.5 m 100 g dry wt	NG	Chicago area cancer patients	Tietz, Hirsch, and Neyman, 1957
	143	ES	45-150 µg/g ash	82 µg/g ash	Adults	Tipton and Cook, 1963
Larynx	35	ES	NG	8 ± 1.1 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	35	ES	2-18 µg/g ash	6 µg/g ash	Adults	Tipton and Cook, 1963
Liver	NG	ES	NG	0.205 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	104	AAS			Male autopsies at Birmingham hospital:	Morgan, 1972a
			NG	138 µg/g ash	controls	
			NG	142 µg/g ash	emphysema	
			NG	184 µg/g ash	emphysema and cancer	
			NG	153 µg/g ash	cancer	
	315	ES	NG	0.53 ± 0.02 mg/100 g dry wt	Above 1 year old	Nusbaum et al., 1958
	150	ES	1.0-4.0 micromoles/g ash	NG	St. Louis adults who died unexpectedly	Perry et al., 1962
	100	ES	1.5-4.2 micromoles/g ash	NG	Adults	Perry, 1968
	10	ES	NG	28.5 ± 114 µg/g ash	St. Louis area male residents killed in accidents	Perry et al., 1973
	NG	NG	NG	4.65 µg/g dry wt		Rentoul and Smith, 1973
	148	ES	NG	130 ± 7.0 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	NG	ES	0-1.5 mg/100 g dry wt	NG	Chicago area cancer patients	Tietz, Hirsch, and Neyman, 1957
	7	Ch and/or	NG	1.3 ± 0.3 ppm wet wt	Noncirrhotic patients	Vallee et al., 1957
	5	ES	NG	17 ± 0.56 ppm wet wt	Cirrhotic patients	
	148	ES	55-220 µg/g ash	100 µg/g ash	Adults	Tipton and Cook, 1963
	NG	ES	NG	0.022 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940

Table 54. Manganese (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	97	ES	NG	0.18 ± 0.01 mg/100 g dry wt	Above 1 year old	Nusbaum et al., 1958
	150	ES	0.15-0.81 micromole/g ash	NG	St. Louis adults who died unexpectedly	Perry et al., 1962
	100	ES	0.25-1.3 micromoles/g ash	NG	Adults, 10th and 90th percentiles	Perry, 1968
	141	ES	NG	24 ± 2.0 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	NG	ES	0-1 mg/100 g dry wt	NG	Chicago area cancer patients	Tietz, Hirsch, and Neyman, 1957
Lung	141	ES	5-170 µg/g ash	24 µg/g ash	Autopsies from nine cities	Tipton and Shafer, 1964
	141	ES	8-43 µg/g ash	17 µg/g ash	Adults	Tipton and Cook, 1963
Muscle	NG	ES	NG	0.050 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	133	ES	NG	6 ± 0.4 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	133	ES	2-14 µg/g ash	5 µg/g ash	Adults	Tipton and Cook, 1963
Nails	18	ES	6.3×10^{-6} to 3.3×10^{-7}% dry wt	NG	White males, 15-70 years old	Goldblum, Derby, and Lerner, 1953
	6	NAA	0.43-3.81 µg/g	1.91 ± 1.38 µg/g	Thumbnails: children	Kanabrocki et al., 1968
	12	NAA	0.42-1.38 µg/g	0.87 ± 0.31 µg/g	adults	
	13	NAA	NG	0.66 µg/g	Controls	Mahler et al., 1970
	18	NAA	NG	1.199 µg/g	Dialysis patients	
	12	NAA	NG	0.61 µg/g	Uremics	
Omentum	75	ES	NG	48 ± 9.8 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	75	ES	13-78 µg/g ash	29 µg/g ash	Adults	Tipton and Cook, 1963
Ovary	16	ES	NG	18 ± 2.2 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	16	ES	9-32 µg/g ash	16 µg/g ash	Adults	Tipton and Cook, 1963
Pancreas	138	ES	NG	110 ± 4.9 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	138	ES	54-200 µg/g ash	98 µg/g ash	Adults	Tipton and Cook, 1963

Table 54. Manganese (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Placenta	58	NG	NG	0.115 ± 0.011 μg/g wet wt	Southern and southeastern hospital patients	Karp and Robertson, 1977
Prostate	50	ES	NG	19 ± 2.9 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	50	ES	7-28 μg/g ash	14 μg/g ash	Adults	Tipton and Cook, 1963
Saliva	21	NAA	0.05-0.79 μg/100 ml	0.28 ± 0.06 μg/100 ml	Normal adults	Kanabrocki et al., 1965*b*
Skin	18	ES	2.4×10^{-8} to 6.1×10^{-7}% dry wt	NG	White males, 15-70 years old	Goldblum, Derby, and Lerner, 1953
	22	ES	NG	22 ± 10.0 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	22	ES	6-17 μg/g ash	13 μg/g ash	Adults from 15 cities	Tipton and Cook, 1963
Spleen	NG	ES	NG	0.022 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	98	ES	NG	0.14 ± 0.01 mg/g dry wt	Above 1 year of age	Nusbaum et al., 1958
	100	ES	0.19-0.74 micromole/g ash	NG	Adults, 10th and 90th percentiles	Perry, 1968
	143	ES	NG	11 ± 0.8 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	143	ES	5-19 μg/g ash	9 μg/g ash	Adults	Tipton and Cook, 1963
Stomach	NG	ES	NG	0.030 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	129	ES	NG	47 ± 2.5 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	129	ES	22-74 μg/g ash	42 μg/g ash	Adults	Tipton and Cook, 1963
Teeth	56	MS	0.08-1.10 μg/g	0.32 ± 0.00 μg/g	Subjects less than 20 years old, enamel	Losee, Cutress, and Brown, 1973
Testis	72	ES	NG	14 ± 0.6 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	72	ES	8-21 μg/g ash	12 μg/g ash	Adults	Tipton and Cook, 1963
Thyroid	21	ES	NG	19 ± 2.3 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	21	ES	9-35 μg/g ash	17 μg/g ash	Adults	Tipton and Cook, 1963

Table 54. Manganese (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Total body content	168	NG	NG	12 mg	Autopsies from 58 cities and 29 rural areas	Schroeder, 1970*b*
Trachea	54	ES	NG	14 ± 1.0 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	54	ES	7-24 µg/g ash	12 µg/g ash	Adults	Tipton and Cook, 1963
Urine	16	NAA	NG	0.82 ± 0.34 µg/day	Dialyzed urine	Kanabrocki et al., 1965*a*
	NG	ES	NG	0.01 mg/liter		Kehoe, Cholak, and Story, 1940
	24	ES	<12-66 µg/liter	<26.7 µg/liter	Normal Americans, ages 4-69 years	Perry and Perry, 1959
	10	ES		<23.4 µg/liter	Females	
	14	ES		<29.1 µg/liter	Males	
	10	ES		<30.3 µg/liter	Negroes	
	14	ES		<25.1 µg/liter	Caucasians	
	8	ES			American hypercholesterolemic patients, ages 21-63 years:	Perry and Perry, 1959
			NG	<15.3 µg/liter	before Na_2Ca EDTA administration	
			NG	28.4 µg/liter	during Na_2Ca EDTA administration	
			NG	23.5 µg/liter	after Na_2Ca EDTA administration	
	15	NG	NG	35 ppb	Normotensive	Perry, 1968
	15	NG	NG	65 ppb	Hypertensive	
	2	FP	NG	0.043 ± 0.008 mg/day 0.053 ± 0.016 mg/day		Tipton, Stewart, and Dickson, 1969
Uterus	31	ES	NG	12 ± 1.3 ppm ash	Adults from 15 cities	Schroeder, Balassa, and Tipton, 1966
	31	ES	7-20 µg/g ash	10 µg/g ash	Adults	Tipton and Cook, 1963

Table 55. Mercury

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	1	C	NG	0.008 ppm	46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
Adrenal	59	AAS, C	2.0-15.8 ppm	NG	Autopsies	Kevorkian et al., 1972
Blood	929	AAS	NG	0.048 ± 0.044 µg/g dry wt	Four hospitals in Nashville, Tennessee, maternal blood	Baglan et al., 1974
	872	AAS	NG	0.054 ± 0.048 µg/g dry wt	Four hospitals in Nashville, Tennessee, fetal blood	Baglan et al., 1974
	54	C	0.5-6.0 µg/10 g	NG	Females, ages 17-49 years, rural Ohio	Benning, 1958
	NG	NG			Michigan residents:	Eyl, 1971
			NG	52 ppb	whole blood	
			NG	96 ppb	red blood cells	
	38	AAS			Plasma:	Galster, 1976
			NG	5.8 ± 0.7 ng/ml	coastal Alaska	
			NG	5.0 ± 0.8 ng/ml	interior Alaska	
			NG	2.6 ± 0.3 ng/ml	urban mothers	
	38	AAS			Red blood cells:	Galster, 1976
			NG	33.5 ± 5.1 ng/ml	coastal Alaska	
			NG	22.6 ± 3.0 ng/ml	interior Alaska	
			NG	8.9 ± 0.9 ng/ml	urban mothers	
	38	AAS			Plasma:	Galster, 1976
			NG	4.5 ± 0.4 ng/ml	coastal Alaska	
			NG	5.0 ± 0.8 ng/ml	interior Alaska	
			NG	3.3 ± 0.5 ng/ml	urban infants	
	38	AAS			Red blood cells:	Galster, 1976
			NG	60.2 ± 10.0 ng/ml	coastal Alaska	
			NG	32.5 ± 6.0 ng/ml	interior Alaska	
			NG	10.8 ± 1.6 ng/ml	urban infants	
	39	XRS	0.00-0.31 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964
	22	C	0.0-22.5 µg/100 ml	7.6 µg/100 ml		Goldwater and Nicolau, 1966
	210	AAS	0-30 ppb	8 ppb	Upper middle class, Washington, D.C.	Goudy et al., 1977
	16	NG	<1.0-2.5 ppm	1.0 ppm	Mother, Buffalo, New York	Hartung and Dinman, 1972
	NG	NG			Maternal blood:	Koos and Longo, 1976
			<3300 ng/ml	NG	exposed	
			0.001-0.017 µg/g	NG	normals	

Table 55. Mercury (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	NG	NG				
			<3000 ng/ml	NG	Fetal blood: exposed	Koos and Longo, 1976
			0.001-0.020 µg/g		normals	
		AAS				
	10		NG	1.6 ± 0.3 ng/ml	Plasma: Rochester	Magos and Clarkson, 1972
	10		NG	2.4 ± 0.4 ng/ml	Alaska	
				1.0 ± 0.2 ng/ml	Alaska	
	50	NAA	0.003-0.017 ppm wet wt	0.008 ppm wet wt	Red blood cells	Massaro, Yaffe, and Thomas, 1974
	50	NAA	0.002-0.011 ppm wet wt	0.007 ppm wet wt	Plasma	Massaro, Yaffe, and Thomas, 1974
	170	AAS				
			0-8 ppb	NG	Maternal, umbilical cord: Iowa City area	Pitkin et al., 1976
			0-6 ppb	NG	Chicago area	
	NG	NG	NG	0.02 µg/ml	Normal level	Rentoul and Smith, 1973
Brain	6	NG	NG	0.05 ppm	Fetus, Buffalo, New York	Hartung and Dinman, 1972
	28	CC, GC-EC	NG	0.093 ppm	Autopsies, age 4-74 years, 1913-1972	Kevorkian et al., 1973
	59	AAS, C	1.3-34.0 ppm	NG	Autopsies	Kevorkian et al., 1972
	NG	NAA	0.02-2.59 ppm wet wt	NG		Massaro, Yaffe, and Thomas, 1974
	113	AAS				
					Autopsies, 26-week-old fetuses, Puget Sound area, urban and rural:	Mottet and Body, 1974
			0.006-0.965 µg/g wet wt	0.132 µg/g wet wt	cerebellum	
			0.008-0.470 µg/g wet wt	0.081 µg/g wet wt	cerebrum	
	NG	NG	NG	2.94 µg/g dry wt	Normal level	Rentoul and Smith, 1973
Diaphragm	59	AAS, C	NG	11.8 ppm	Autopsies	Kevorkian et al., 1972
Gastrointestinal tract	1	C	NG	0.008 ppm	46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
Hair	230	AAS	NG	1.35 µg/g dry wt (median)	Maternal hair, four hospitals in Nashville, Tennessee	Baglan et al., 1974
	94	AAS	NG	2.73 µg/g dry wt (median)	Fetal hair, four hospitals in Nashville, Tennessee	Baglan et al., 1974
	33	NAA	0.1-33 ppm	7.6 ppm	Adults and children, Oak Ridge, Tennessee	Benning, 1958

Table 55. Mercury (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	1000	AAS	0.12-139.0 ppm	4.18 ppm (2.45 males, 5.90 females)	Idaho	Benson and Gabica, 1972
		AAS			Three New York City communities:	Creason et al., 1975
	280		0.048-11.30 µg/g	0.672 µg/g	children	
	203		0.05-14 µg/g	0.774 µg/g	adults	
	25	AAS	0.2-12.4 ppm	5.4 ppm	Men, age 9-60 years	Eads and Lambdin, 1973
	25	AAS	0.1-30 ppm	5.5 ppm	Women, age 13-72 years	
	38	AAS	NG	4.257 ± 0.621 µg/g	Coastal Alaska	Galster, 1976
			NG	3.57 ± 0.740 µg/g	Interior Alaska	
			NG	4.045 ± 0.796 µg/g	Urban mothers	
	NG	AAS, GC	5.3-125 µg/g	NG		Giovanoli-Jakubczak et al., 1974
	327	AAS	5-90 ppm	20.4 ppm	Los Alamos, 80 men and 147 women	Nord, Kadaba, and Sorenson, 1973
	99	AAS	5-100 ppm	29.6 ppm	Pasadena, women	
	10	NAA	NG	1.243 ± 0.029 ppm	Homogenized hair	Obrusnik et al., 1972
	NG	NG	NG	5.52 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	145	NG	492-12,000 ppb	1708 ppb	Women	Sell, Deitz, and Buchanan, 1975
			190-6143 ppb		Men	
Heart	1	C	NG	0.052 ppm	46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
	28	CC, GC-EC	0.047 ppm	NG	Autopsies, age 4-74 years, 1913-1972	Kevorkian et al., 1973
	59	AAS, C	1.1-10.4 ppm	NG	Autopsies	Kevorkian et al., 1972
	113	AAS	0.012-0.704 µg/g wet wt	0.102 µg/g wet wt	Autopsies, 26-week-old fetuses, Puget Sound, urban and rural	Mottet and Body, 1974
	NG	NG	NG	1.76 µg/g dry wt	Normal level	Rentoul and Smith, 1973
Kidney	28	CC, GC-EC	0-0.40 ppm	NG	Autopsies, age 4-74 years, 1913-1972, methylmercury	Kevorkian et al., 1973
	59	AAS, C	1.6-27.2 ppm	NG	Autopsies	Kevorkian et al., 1972
		NAA				
	6		0.14-2.3 µg/g dry wt	0.99 ± 0.84 µg/g dry wt	Autopsies: infants	Livingstone, 1971
	32		0.35-5.3 µg/g dry wt	9.4 ± 14 µg/g dry wt	adults	

Table 55. Mercury (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
		NAA			Renal cortex:	Livingstone, 1972
	32		0.35-53 µg/g	9.4 µg/g	adults	
	6		0.14-23 µg/g	0.99 µg/g	infants	
	113	AAS	0.006-6.40 µg/g wet wt	0.759 µg/g wet wt	Autopsies, 26-week-old fetuses, Puget Sound, urban and rural	Mottet and Body, 1974
	NG	NG	NG	9.03 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	45	AAS	0.075-3.36 ppm	0.762 ppm wet wt	30 males and 15 females	Stein et al., 1974
Liver	1	C	NG	0.005 ppm	46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
	10	NG	0.02-0.10 ppm	0.06 ppm	Stillbirths, Buffalo, New York	Hartung and Dinman, 1972
	43	NG	<0.01-0.39 ppm	0.06 ppm	Fetus, Buffalo, New York	Hartung and Dinman, 1972
	59	AAS, C	3.0-19.9 ppm	NG	Autopsies	Kevorkian et al., 1972
	113	AAS	0.008-1.43 µg/g wet wt	0.250 µg/g wet wt	Autopsies, 26-week-old fetuses, Puget Sound, urban and rural	Mottet and Body, 1974
	NG	NG	NG	3.66 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	20	AAS	0.026-0.545 ppm	0.172 ppm wet wt	30 males and 15 females	Stein et al., 1974
Lung	1	C	NG	0.017 ppm	46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
	59	AAS, C	2.0-34.4 ppm	NG	Autopsies	Kevorkian et al., 1972
	113	AAS	0.0-2.763 µg/g wet wt	0.251 µg/g wet wt	Autopsies, 26-week-old fetuses, Puget Sound, rural and urban	Mottet and Body, 1974
	47	AAS	0.007-1.5 ppm wet wt	0.03 ppm wet wt	30 males and 15 females	Stein et al., 1974
Milk	38	AAS			Mothers:	Galster, 1976
			NG	7.6 ± 2.7 ng/ml	coastal Alaska	
			NG	3.2 ± 0.8 ng/ml	interior Alaska	
			NG	3.3 ± 0.5 ng/ml	urban	
	NG	NG	<200 ng/ml	NG	Exposed	Koos and Longo, 1976
	170	AAS	NG	0.93 ppb	Iowa City and Chicago areas	Pitkin et al., 1976
Muscle	1	C	NG	0.020 ppm	46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
	59	AAS, C	3.0-11.1 ppm	NG	Autopsies	Kevorkian et al., 1972

Table 55. Mercury (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	113	AAS	0.0-0.954 µg/g wet wt	0.126 µg/g wet wt	Autopsies, 26-week-old fetuses, Puget Sound, urban and rural	Mottet and Body, 1974
Nerve	1	C	NG	0.047 ppm	46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
Offal	1	C	NG	0.024 ppm	46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
Ovary	59	AAS, C	NG	0.2 ppm	Autopsies	Kevorkian et al., 1972
Pancreas	59	AAS, C	0.9-29.6 ppm	NG	Autopsies	Kevorkian et al., 1972
	113	AAS	0.007-0.511 µg/g wet wt	0.065 µg/g wet wt	Autopsies, 26-week-old fetuses, Puget Sound, urban and rural	Mottet and Body, 1974
Placenta	10	AAS	NG	0.129 ± 0.161 µg/g dry wt	Four hospitals, Nashville, Tennessee	Baglan et al., 1974
	54	C	NG	1.53 µg/10 g	Females, age 17-49 years, rural Ohio	Benning, 1958
	38	AAS	NG NG NG	38.9 ± 5.1 ng/g 30.7 ± 14.8 ng/g 11.6 ± 1.3 ng/g	Mothers: coastal Alaska interior Alaska urban	Galster, 1976
	58	NG	NG	0.014 ± 0.001 µg/g wet wt	Southern and southeastern city hospitals	Karp and Robertson, 1977
	113	AAS	0.010-0.803 µg/g wet wt	0.087 µg/g wet wt	Autopsies, 26-week-old fetuses, Puget Sound, urban and rural, cord	Mottet and Body, 1974
	170	AAS	NG	2.28 ppb	Iowa City and Chicago areas	Pitkin et al., 1976
Skin	1	C	NG	0.003 ppm	46-year-old cadaver	Forbes, Cooper, and Mitchell, 1954
	113	AAS	0.004-1.275 µg/g wet wt	0.193 µg/g wet wt	Autopsies, 26-week-old fetuses, Puget Sound, urban and rural	Mottet and Body, 1974
Spleen	59	AAS, C	1.8-18.8 ppm	NG	Autopsies	Kevorkian et al., 1972
	113	AAS	0.012-1.205 µg/g wet wt	0.122 µg/g wet wt	Autopsies, 26-week-old fetuses, Puget Sound, urban and rural	Mottet and Body, 1974

Table 55. Mercury (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Teeth	38	C	NG	5.3 ± 5.4 µg/g	California	Kuhnlein and Calloway, 1977
Testis	59	AAS, C	1.9-7.8 ppm	NG	Autopsies	Kevorkian et al., 1972
Thyroid	59	AAS, C	NG	0.1 ppm	Autopsies	Kevorkian et al., 1972
Urine	54	C	NG	10-3740 µg/liter	Females, age 17-48 years, rural Ohio	Benning, 1958
	22	C	4.5-118.5 µg/liter 0-22.5 µg/liter	34.0 µg/liter 4.5 µg/liter	10 exposed 12 control	Goldwater and Nicolau, 1966
	68 of 308	NG	0-221.0 µg/liter	NG	New York City, California, and Ohio	Jacobs, Ladd, and Goldwater, 1964
	NG	NG	<2.91 µg/ml	NG	Exposed mothers	Koos and Longo, 1976
	NG	NG	0.003-0.017 ppm wet wt	0.008 ppm wet wt		Massaro, Yaffe, and Thomas, 1974
	NG	NG	NG	0.023 µg/g dry wt	Normal level	Rentoul and Smith, 1973
Uterus	59	AAS, C	11.7-20.5 ppm	NG	Autopsies	Kevorkian et al., 1972

Table 56. Mirex

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	507	NG	NG	5.2 ppm (highest value)	8 southern states, 20% of the samples positive	Anonymous, 1978
	NG	GC-EC	0.16-5.94 ppm in 6 positive cases	2.50 ppm (mean of 6 positives)	Results from National Monitoring Program, April 1971-April 1972	Kutz et al., 1974*a*
Human tissues	186	NG	<1.0-1.32 ppm	0.38 ppm (0.08 ppm if negatives included)	Samples taken in treatment areas	Anonymous, 1976
Milk	1436	GC-EC	NG	ND	Limit of detectability, 30 ppb	Savage, 1976

Table 57. Molybdenum

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	177	ES	NG	5.1 µg/g ash	Accident victims	Schroeder, Balassa, and Tipton, 1970
Adrenal	177	ES	NG	15.0 µg/g ash	Accident victims	Schroeder, Balassa, and Tipton, 1970
	10 of 13	ES	<4.0-22.0 µg/g ash	15 µg/g ash (median)	Autopsies, nine U.S. cities	Tipton and Cook, 1963
Aorta	177	ES	NG	<2.0 µg/g ash	Accident victims	Schroeder, Balassa, and Tipton, 1970
	3 of 104	ES	<4.0-<4.0 µg/g ash	<4.0 µg/g ash (median)	Autopsies, nine U.S. cities	Tipton and Cook, 1963
Bladder	2	ES	NG	0.02 ppm	Sudden accident victims	Koch et al., 1956
	177	ES	NG	<2.0 µg/g ash	Accident victims	Schroeder, Balassa, and Tipton, 1970
	6 of 110	ES	<4.0-<4.0 µg/g ash	<4.0 µg/g ash (median)	Autopsies, nine U.S. cities	Tipton and Cook, 1963
Blood	229	C	0.50-15.73 µg/100 ml	0.50-41.0 µg/100 ml	Whole blood: 48 of 229 samples had undetectable amounts (<0.5 µg/100 ml)	Allaway et al., 1968
	266	ES			Patients, blood donors, and normal individuals, Los Angeles area:	.Butt et al., 1964
			NG	0.0021 mg/100 ml	serum	
			NG	0.0072 mg/100 ml	whole blood	
	39	XRS	0.10-0.30 ppm	NG	Healthy males, mean age 35.3 years, blood serum	Gofman et al., 1964
Bone	177	ES	NG	<4.0 µg/g ash	Accident victims	Schroeder, Balassa, and Tipton, 1970
Brain	3	ES	NG	<0.02 ppm	Sudden accident victims	Koch et al., 1956
	177	ES	NG	2.0 µg/g ash	Accident victims	Schroeder, Balassa, and Tipton, 1970
	3 of 129	ES	<4.0-<4.0 µg/g ash	<4.0 µg/g ash (median)	Autopsies, nine U.S. cities	Tipton and Cook, 1963
Diaphragm	177	ES	NG	3.0 µg/g ash	Accident victims	Schroeder, Balassa, and Tipton, 1970
	3 of 91	ES	<4.0-<4.0 µg/g ash	<4.0 µg/g ash (median)	Autopsies, nine U.S. cities	Tipton and Cook, 1963
Esophagus	177	ES	NG	<2.0 µg/g ash	Accident victims	Schroeder, Balassa, and Tipton, 1970

Table 57. Molybdenum (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	1 of 66	ES	<4.0-<4.0 µg/g ash	<4.0 µg/g ash (median)	Autopsies, nine U.S. cities	Tipton and Cook, 1963
Feces	2	ES	NG	0.088 ± 0.017 and 0.099 ± 0.015 mg/day	Healthy males, Cincinnati, Ohio	Tipton, Stewart, and Dickson, 1969
Hair	2	AAS, MS	NG	0.13 and 0.28 µg/g dry wt	None	Yurachek, Clemena, and Harrison, 1969
Heart	177	ES	NG	3.8 µg/g ash	Accident victims	Schroeder, Balassa, and Tipton, 1970
	8 of 140	ES	<4.0-<4.0 µg/g ash	<4.0 µg/g ash (median)	Autopsies, nine U.S. cities	Tipton and Cook, 1963
Intestine						
Large intestine	1	ES	NG	<0.02 ppm	Sudden accident victims	Koch et al., 1956
Small intestine	7	ES	NG	0.04 ppm	Sudden accident victims	Koch et al., 1956
Duodenum	177	ES	NG	4.0 µg/g ash	Adult	Schroeder, Balassa, and Tipton, 1970
Jejunum	177	ES	NG	4.0-5.5 µg/g ash	Adult	Schroeder, Balassa, and Tipton, 1970
Ileum	177	ES	NG	<4.0 µg/g ash	Adult	Schroeder, Balassa, and Tipton, 1970
Cecum	177	ES	NG	<4.0 µg/g ash	Adult	Schroeder, Balassa, and Tipton, 1970
Sigmoid colon	177	ES	NG	2.5 µg/g ash	Adult	Schroeder, Balassa, and Tipton, 1970
Rectum	177	ES	NG	2.0 µg/g ash	Adult	Schroeder, Balassa, and Tipton, 1970
Duodenum	6 of 67	ES	<4.0-<4.0 µg/g ash	<4.0 µg/g ash	Adult	Tipton and Cook, 1963
Jejunum	7 of 102	ES	<4.0-<4.0 µg/g ash	<4.0 µg/g ash	Adult	Tipton and Cook, 1963
Ileum	18 of 83	ES	<4.0-9.0 µg/g ash	<4.0 µg/g ash	Adult	Tipton and Cook, 1963
Cecum	6 of 31	ES	<4.0-5.0 µg/g ash	<4.0 µg/g ash	Adult	Tipton and Cook, 1963
Sigmoid colon	4 of 108	ES	<4.0-<4.0 µg/g ash	<4.0 µg/g ash	Adult	Tipton and Cook, 1963
Rectum	2 of 42	ES	<4.0-<4.0 µg/g ash	<4.0 µg/g ash	Adult	Tipton and Cook, 1963
Kidney	6	ES	NG	0.24 ppm	Sudden accident victims	Koch et al., 1956

Table 57. Molybdenum (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	6	C	0.8–2.5 µg/g dry wt	1.86 µg/g dry wt		Koch, Smith, and McNelly, 1957
	177	ES	15.0–31.0 µg/g ash	NG	Accident victims	Schroeder, Balassa, and Tipton, 1970
	NG	ES	0.0–0.5+ mg/100 g dry wt	NG		Tietz, Hirsch, and Neyman, 1957
	140 of 144	ES	20.0–48.0 µg/g ash	31.0 µg/g ash		Tipton and Cook, 1963
Larynx	177	ES	NG	<4.0 µg/g ash	Accident victims	Schroeder, Balassa, and Tipton, 1970
	1 of 50	ES	<4.0–<4.0 µg/g ash	<4.0 µg/g ash (median)		Tipton and Cook, 1963
Liver	5	ES	NG	0.7 ppm	Sudden accident victims	Koch et al., 1956
	5	C	2.8–9.6 µg/g dry wt	5.2 µg/g dry wt		Koch, Smith, and McNelly, 1957
	29	ES	0.15–0.86 µg/g wet wt	0.55 µg/g wet wt	Noncancerous deaths	Olson, Heggen, and Edwards, 1958
	10	ES	NG	228 ± 178 µg/g ash	Male accident victims, five black and five white	Perry et al., 1973
	177	ES	53.0–77.0 µg/g ash	NG	Accident victims	Schroeder, Balassa, and Tipton, 1970
	NG	ES	0.0–2.0 mg/100 g dry wt	NG		Tietz, Hirsch, and Neyman, 1957
	147	ES	32.0–140.0 µg/g ash	75.0 µg/g ash		Tipton and Cook, 1963
Lung	4	ES	NG	0.24 ppm	Sudden accident victims	Koch et al., 1956
	4	C	0.2–6.1 µg/g dry wt	2.2 µg/g dry wt		Koch, Smith, and McNelly, 1957
	168	NG	NG	Min – 20 µg, max – 200 µg, retained per year – 0.0	Autopsy samples from 58 cities and 29 nonurban areas	Schroeder, 1970*b*
	177	ES	NG	2.7 µg/g ash	Accident victims	Schroeder, Balassa, and Tipton, 1970
	NG	ES	0.0–0.3+	NG		Tietz, Hirsch, and Neyman, 1957
	5 of 141	ES	<4.0–20.0 µg/g ash	<4.0 µg/g ash	Autopsies, nine U.S. cities	Tipton and Shafer, 1964
	5 of 141	ES	<4.0–<4.0 µg/g ash	<4.0 µg/g ash		Tipton and Cook, 1963

Table 57. Molybdenum (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Muscle	8	ES	NG	0.03 ppm	Sudden accident victims	Koch et al., 1956
	177	ES	NG	<4.0 µg/g ash	Accident victims	Schroeder, Balassa, and Tipton, 1970
	2 of 136	ES	<4.0-<4.0 µg/g ash	<4.0 µg/g ash		Tipton and Cook, 1963
Omentum	177	ES	<4.0-12.0 µg/g ash	NG	Accident victims	Schroeder, Balassa, and Tipton, 1970
Ovary	0 of 16	ES	<4.0-<4.0 µg/g ash	<4.0 µg/g ash		Tipton and Cook, 1963
Pancreas	1	ES	NG	0.03 ppm	Sudden accident victims	Koch et al., 1956
	177	ES	NG	3.2 µg/g ash	Accident victims	Schroeder, Balassa, and Tipton, 1970
	12 of 139	ES	<4.0-<4.0 µg/g ash	<4.0 µg/g ash		Tipton and Cook, 1963
Prostate	177	ES	NG	3.9 µg/g ash	Accident victims	Schroeder, Balassa, and Tipton, 1970
	2 of 50	ES	<4.0-<4.0 µg/g ash	<4.0 µg/g ash		Tipton and Cook, 1963
Skin	177	ES	NG	<2.0 µg/g ash	Accident victims	Schroeder, Balassa, and Tipton, 1970
	2 of 22	ES	<4.0-<4.0 µg/g ash	<4.0 µg/g ash		Tipton and Cook, 1963
Spleen	3	ES	NG	0.1 ppm	Sudden accident victims	Koch et al., 1956
	3	C	0.0-1.2 µg/g dry wt	0.5 µg/g dry wt		Koch et al., 1956
	177	ES	NG	4.2 µg/g ash	Accident victims	Schroeder, Balassa, and Tipton, 1970
	4 of 143	ES	<4.0-<4.0 µg/g ash	<4.0 µg/g ash		Tipton and Cook, 1963
Stomach	3	ES	NG	0.08 ppm	Sudden accident victims	Koch et al., 1956
	177	ES	NG	3.0 µg/g ash	Accident victims	Schroeder, Balassa, and Tipton, 1970
	11 of 130	ES	<4.0-<4.0 µg/g ash	<4.0 µg/g ash		Tipton and Cook, 1963
Testis	1	ES	NG	0.03 ppm	Sudden accident victims	Koch et al., 1956
	177	ES	NG	3.1 µg/g ash	Accident victims	Schroeder, Balassa, and Tipton, 1970
	2 of 72	ES	<4.0-<4.0 µg/g ash	<4.0 µg/g ash		Tipton and Cook, 1963

Table 57. Molybdenum (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Teeth	56	MS	0.7-39.0 µg/g	5.5 ± 0.71 µg/g	Subjects less than 20 years old, wide geographic area	Losee, Cutress, and Brown, 1973
Thyroid	177	ES	NG	3.4 µg/g ash	Accident victims	Schroeder, Balassa, and Tipton, 1970
	1 of 21	ES	<4.0-<4.0 µg/g ash	<4.0 µg/g ash		Tipton and Cook, 1963
Trachea	177	ES	NG	<2.0 µg/g ash	Accident victims	Schroeder, Balassa, and Tipton, 1970
	1 of 60	ES	<4.0-<4.0 µg/g ash	<4.0 µg/g ash		Tipton and Cook, 1963
Urine	32	ES	12-150 µg/liter	29.0-46.9 µg/liter	Mixed population, ages 4-69 years	Perry and Perry, 1959
	23	NG	NG	4.5-15.0 ppb		Perry, 1968
	2	ES	NG	0.11 ± 0.01 and 0.13 ± 0.01 mg/day	Healthy males, Cincinnati, Ohio	Tipton, Stewart, and Dickson, 1969
Uterus	177	ES	NG	<2.0 µg/g ash	Accident victims	Schroeder, Balassa, and Tipton, 1970
	1 of 32	ES	<4.0-<4.0 µg/g ash	<4.0 µg/g ash		Tipton and Cook, 1963

Table 58. Neodymium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.0-0.08 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964
Teeth	56	MS	0.02-0.09 µg/g dry wt	0.045 µg/g dry wt	Subjects less than 20 years old, wide geographic area	Losee, Cutress, and Brown, 1973

Table 59. Nickel

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adrenal	10 of 13	ES	<5.0-60.0 µg/g ash	10.0 µg/g ash (median)		Tipton and Cook, 1963
Aorta	150	ES	0.09-0.34 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	47 of 104	ES	<5.0-20.0 µg/g ash	<5.0 µg/g ash (median)		Tipton and Cook, 1963
Bladder	2	ES	NG	0.7 ppm wet wt	Sudden accident victims, ages 21-37	Koch et al., 1956
	46 of 110	ES	<5.0-20.0 µg/g ash	<5.0 µg/g ash (median)		Tipton and Cook, 1963
Blood	30 of 48	ES			Normal individuals, Los Angeles area:	Butt et al., 1964
			NG	0.0053-0.0062 mg/100 ml	serum	
			NG	0.0327-0.0010 mg/100 ml	whole blood	
	39	XRS	0.0-0.18 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964
	48	AAS	1.1-4.5 µg/liter	3.1 µg/liter	Males	Hohnadel et al., 1973
	11		0.4-4.6 µg/liter	2.7 µg/liter	Females	
	150	ES	0.0-45 µg/100 g	3.0 µg/100 g	Adult males, U.S. cities	Imbus et al., 1963
	8	ES	1.0-8.5 µg/100 ml	3.0 µg/100 ml	Sudden accident victims, ages 21-37, plasma	Koch et al., 1956
	26	AAS	0.8-5.2 µg/liter	2.6 µg/liter	Hartford, Connecticut	McNeeley, Nechay, and Sunderman, 1972
	47	AAS	NG	2.6 ± 0.8 µg/liter	Elevated in some diseased patients	McNeeley et al., 1971
	NG	NG	3.0-8.0 µg/liter	NG	Metabolism of nickel	Mertz, 1974
	NG	NG	NG	0.03 µg/ml	Normal values	Rentoul and Smith, 1973
Bone	40	AAS	23.4-81.0 µg/g dry wt	51.0 µg/g dry wt	Possible relation to osteogenic sarcoma	Janes, McCall, and Elveback, 1972
	2	ES	NG	0.16 ppm wet wt	Sudden accident victims, ages 23-37	Koch et al., 1956
Brain	3	ES	NG	0.08 ppm wet wt	Sudden accident victims, ages 21-37	Koch et al., 1956
	NG	NG	NG	0.3 µg/g dry wt	Normal values	Rentoul and Smith, 1973
	9 of 129	ES	<5.0-<5.0 µg/g ash	<5.0 µg/g ash (median)		Tipton and Cook, 1963

Table 59. Nickel (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Diaphragm	28 of 81	ES	<5.0-19.0 µg/g ash	<5.0 µg/g ash (median)		Tipton and Cook, 1963
Esophagus	22 of 66	ES	<5.0-27.0 µg/g ash	<5.0 µg/g ash (median)		Tipton and Cook, 1963
Feces	2	ES	NG	0.22 ± 0.03 and 0.35 ± 0.05 mg/day	Healthy males, Cincinnati, Ohio	Tipton, Stewart, and Dickson, 1969
Hair	498	NG	0.036 to 11.0 µg/g 0.045 to 11.0 µg/g	0.51 µg/g 0.74 µg/g	New York metropolitan area: children adults	Creason et al., 1975
	50	AAS	0.9-7.2 ppm 0.7-7.5 ppm	1.9 ppm 3.4 ppm	Males, 9-60 years old Females, 13-72 years old	Eads and Lambdin, 1973
	12	AAS	0.8-15.6 µg/g	3.7 µg/g	General population, mixed sample	Hinners et al., 1974
	NG	NG	NG	6.0 µg/g dry wt	Normal values	Rentoul and Smith, 1973
	180	AAS	NG NG	0.97 ± 0.15 µg/g 3.96 ± 1.10 µg/g	No dyed or bleached hair: males females	Schroeder and Nason, 1969
	2	AAS, MS	NG	0.45 and 3.4 µg/g dry wt	Methodology	Yurachek, Ciemena, and Harrison, 1969
Heart	150	ES	0.09-0.46 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	NG	NG	NG	0.2 µg/g dry wt	Normal values	Rentoul and Smith, 1973
	4	AAS	0.43-0.83 µg/100 g wet wt 1.6-3.0 µg/100 g dry wt	0.61 µg/100 g wet wt 2.3 µg/100 g dry wt		Sunderman, Nomoto, and Nechay, 1970
	48 of 140	ES	<5.0-27.0 µg/g ash	<5.0 µg/g ash (median)		Tipton and Cook, 1963
Intestine						
Large intestine	1 of 7	ES	NG	0.08 ppm wet wt	Sudden accident victims, ages 21-37	Koch et al., 1956
Small intestine	1 of 7	ES	NG	1.06 ppm wet wt	Sudden accident victims, ages 21-37	Koch et al., 1956
	2652	ES	NG	30 ppm ash	Seven cities	Schroeder, Balassa, and Tipton, 1962*b*
Duodenum	35 of 67	ES	<5.0-16.0 µg/g ash	5.0 µg/g ash (median)		Tipton and Cook, 1963
Jejunum	21 of 102	ES	<5.0-11.0 µg/g ash	<5.0 µg/g ash (median)		Tipton and Cook, 1963
Ileum	52 of 84	ES	<5.0-44.0 µg/g ash	9.0 µg/g ash (median)		Tipton and Cook, 1963

Table 59. Nickel (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Cecum	29 of 31	ES	5.0-100.0 µg/g ash	21.0 µg/g ash (median)		Tipton and Cook, 1963
Sigmoid colon	81 of 108	ES	<5.0-55.0 µg/g ash	12.0 µg/g ash (median)		Tipton and Cook, 1963
Rectum	2 of 24	ES	5.0-38.0 µg/g ash	16.0 µg/g ash (median)		Tipton and Cook, 1963
Kidney	6	ES	0.0-1.4 µg/g dry wt	0.6 µg/g dry wt	Control values	Koch, Smith, and McNelly, 1957
	6	ES	NG	0.04 ppm wet wt	Sudden accident victims, ages 21-37	Koch et al., 1956
	150	ES	0.09-0.19 micromole/g ash	NG	Adults who died unexpectedly, St. Louis, Missouri	Perry et al., 1972
	NG	NG	NG	0.2 µg/g dry wt	Normal values	Rentoul and Smith, 1973
	NG	ES	0-0.5+ mg/100 g dry wt	NG		Tietz, Hirsch, and Neyman, 1957
	30 of 144	ES	<5.0-11.0 µg/g ash	<5.0 µg/g ash (median)		Tipton and Cook, 1963
Larynx	18 of 50	ES	<5.0-17.0 µg/g ash	<5.0 µg/g ash (median)		Tipton and Cook, 1963
Liver	5	ES	0.3-0.8 µg/g dry wt	0.17 µg/g dry wt	Control values	Koch, Smith, and McNelly, 1957
	5	ES	NG	0.16 ppm wet wt	Sudden accident victims, ages 21-37	Koch et al., 1956
	150	ES	0.09-0.19 micromole/g ash	NG	Adults who died unexpectedly, St. Louis, Missouri	Perry et al., 1962
	10	ES	NG	2.6 µg/g ash	Healthy adult males, five white, five black, long-term St. Louis residents	Perry et al., 1973
	4	AAS	0.52-1.32 µg/100 g wet wt 2.1-4.8 µg/100 g dry wt	0.87 µg/100 g wet wt 3.20 µg/100 g dry wt		Sunderman, Nomoto, and Nechay, 1970
	27 of 148	ES	<5.0-11.0 µg/g ash	<5.0 µg/g ash		Tipton and Cook, 1963
Lung	4	ES	0.0-4.6 µg/g dry wt	1.4 µg/g dry wt	Normal values, controls	Koch, Smith, and McNelly, 1957
	4	ES	NG	0.24 ppm wet wt	Sudden accident victims, ages 21-37	Koch et al., 1956
	150	ES	0.09-0.48 micromole/g ash	NG	Adults who died unexpectedly, St. Louis, Missouri	Perry et al., 1962

Table 59. Nickel (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	168	NG	NG	Min – 50 µg/year, max – 8000 µg/year, and retained per year – 10 µg	Autopsies, 58 U.S. cities and urban areas	Schroeder, 1970*b*
	137	ES	7-60 ppm	NG	Seven cities	Schroeder, Balassa, and Tipton, 1962*b*
	4	AAS	0.81-2.4 µg/100 g wet wt 3.3-14.6 µg/100 g dry wt	1.59 µg/100 g wet wt 8.60 µg/100 g dry wt		Sunderman, Nomoto, and Nechay, 1970
	NG	ES	0-0.6+ mg/100 g dry wt	NG		Tietz, Hirsch, and Neyman, 1957
	70 of 141	ES	<5.0-28.0 µg/g ash	<5.0 µg/g ash (median)		Tipton and Cook, 1963
Muscle	7	ES	NG	0.14 ppm wet wt	Sudden accident victims, ages 21-37	Koch et al., 1956
	30 of 136	ES	<5.0-12.0 µg/g ash	<5.0 µg/g ash (median)		Tipton and Cook, 1963
Omentum	63 of 75	ES	<5.0-76.0 µg/g ash	22.0 µg/g ash (median)		Tipton and Cook, 1963
Ovary	4 of 16	ES	<5.0-17.0 µg/g ash	<5.0 µg/g ash (median)		Tipton and Cook, 1963
Pancreas	4	ES	NG	0.16 ppm wet wt	Sudden accident victims, ages 21-37	Koch et al., 1956
	26 of 129	ES	<5.0-11.0 µg/g ash	<5.0 µg/g ash (median)		Tipton and Cook, 1963
Placenta	58	NG	NG	0.006 ± 0.006 µg/g wet wt	South and southeast U.S. areas	Karp and Robertson, 1977
Prostate	4	ES	NG	0.04 ppm wet wt	Sudden accident victims, ages 21-37	Koch et al., 1956
	8 of 50	ES	<5.0-5.0 µg/g ash	<5.0 µg/g ash (median)		Tipton and Cook, 1963
Skin	21 of 22	ES	15.0-180.0 µg/g ash	47.0 µg/g ash (median)		Tipton and Cook, 1963
Spleen	3	ES	0.3-1.0 µg/g dry wt	0.8 µg/g dry wt	Control values	Koch, Smith, and McNelly, 1957
	3	ES	NG	0.10 ppm wet wt	Sudden accident victims, ages 21-37	Koch et al., 1956
	150	ES	0.09-0.09 micromole/g ash	NG	Adults who died unexpectedly, St. Louis, Missouri	Perry et al., 1962
	17 of 143	ES	<5.0-5.0 µg/g ash	<5.0 µg/g ash (median)		Tipton and Cook, 1963

Table 59. Nickel (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Stomach	3	ES	NG	0.36 ppm wet wt	Sudden accident victims, ages 21-37	Koch et al., 1956
	44 of 130	ES	<5.0-18.0 µg/g ash	<5.0 µg/g ash (median)		Tipton and Cook, 1963
Sweat	48	AAS	7-180 µg/liter	52 µg/liter	Males	Hohnadel et al., 1973
	11		39-270 µg/liter	131 µg/liter	Females	
Teeth	56	MS	0.11-3.0 µg/g	0.64 µg/g	Subjects less than 20 years old, wide geographic area	Losee, Cutress, and Brown, 1973
Testis	17 of 72	ES	<5.0-16.0 µg/g ash	<5.0 µg/g ash (median)		Tipton and Cook, 1963
Thyroid	2	FS	NG	0.16 ppm wet wt	Sudden accident victims, ages 21-37	Koch et al., 1956
	7 of 21	ES	<5.0-10.0 µg/g ash	<5.0 µg/g ash (median)		Tipton and Cook, 1963
Trachea	31 of 60	ES	<5.0-15.0 µg/g ash	5.0 µg/g ash (median)		Tipton and Cook, 1963
Urine	NG	NAA	NG	<0.10 mg/liter		Gills et al., 1974
	150	ES	0.0-82 µg/liter	7.6 µg/liter	Adult males, U.S. cities	Imbus et al., 1963
	20	AAS	0.7-4.0 µg/liter	2.0 µg/liter	Hartford, Connecticut	McNeeley, Nechay, and Sunderman, 1972
	NG	NG	10-100 µg/liter	NG	Metabolism of nickel	Mertz, 1974
	24	ES	10-70 µg/liter	20.1 µg/liter 16.6 µg/liter 22.6 µg/liter	Normals, St. Louis, Missouri: overall females males	Perry and Perry, 1959
	15	NG	NG	3.5 ppb	Hypertensives, little difference	Perry, 1968
	2	ES	NG	0.11 ± 0.03 mg/day	Healthy males, Cincinnati, Ohio	Tipton, Stewart, and Dickson, 1969
Uterus	6 of 32	ES	<5.0-6.0 µg/g ash	<5.0 µg/g ash (median)		Tipton and Cook, 1963

Table 60. Niobium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	1-5	C	NG	1.71 µg/g wet wt	Survey for levels	Schroeder and Balassa, 1965
Aorta	1-5	C	NG	6.21 µg/g wet wt	Survey for levels	Schroeder and Balassa, 1965
Blood	39	XRS	0.0-0.16 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964
	1-5	C	0.53-0.74 µg/g wet wt 4.19-64 µg/g wet wt	NG	Survey for levels	Schroeder and Balassa, 1965
Brain	1-5	C	0.31-1.05 µg/g wet wt	NG	Survey for levels	Schroeder and Balassa, 1965
Hair	1-5	C	1.72-2.39 µg/g	NG	Survey for levels	Schroeder and Balassa, 1965
Heart	1-5	C	0.35-0.93 µg/g wet wt	NG	Survey for levels	Schroeder and Balassa, 1965
Kidney	1-5	C	0.66-8.81 µg/g wet wt	NG	Survey for levels	Schroeder and Balassa, 1965
Liver	1-5	C	1.84-5.76 µg/g wet wt	NG	Survey for levels	Schroeder and Balassa, 1965
Lung	1-5	C	0.55-2.67 µg/g wet wt	NG	Survey for levels	Schroeder and Balassa, 1965
Pancreas	1-5	C	0.83-1.18 µg/g wet wt	NG	Survey for levels	Schroeder and Balassa, 1965
Spleen	1-5	C	0.74-1.98 µg/g wet wt	NG	Survey for levels	Schroeder and Balassa, 1965
Teeth	56	MS	<0.10-0.76 µg/g dry wt	0.31 µg/g dry wt	Subjects less than 20 years old, wide geographic area	Losee, Cutress, and Brown, 1973
Testis	1-5	C	0.43-0.80 µg/g wet wt	NG	Survey for levels	Schroeder and Balassa, 1965
Total body content	168	NG	NG	110 mg	Samples from 58 cities and 29 nonurban areas	Schroeder, 1970*b*
Urine	1-5	C	0.24-0.29 µg/ml	NG	Survey for levels	Schroeder and Balassa, 1965

Table 61. *trans*-Nonachlor

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	NG	GC-EC	NG	0.04 ppm 0.06 ppm	Nine U.S. regions: New England states Southwestern central states	Kutz et al., 1976
Milk	57	GC-EC, GC/MS	Trace to 0.01 ppm	0.001 ppm (trace = 0)	Selected areas of Arkansas and Mississippi, 1973-1974, 27% blacks, whole-milk basis	Strassman and Kutz, 1977

Table 62. Osmium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.0-0.57 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964

Table 63. Oxychlordane

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	21 of 27	GC-EC, IA, MS	0.03-0.40 ppm	0.41 ppm		Biros, Walker, and Medberry, 1970
	1734	GC-EC	Trace to 1.73 ppm	0.12, 0.11 ppm, 1973 1974 (geometric mean)	Whites and blacks respectively. Reflective of general U.S. population in conterminous 48 states, lipid basis	Kutz, Yobs, and Strassman, 1977
	240	GC-EC	Trace to 0.89 ppm	0.14, 0.15 ppm, 1973 1974 (geometric mean)		
	3906	GC-EC	Trace to 1.87 ppm	0.11-0.12 ppm (geometric mean) FY 1972-FY 1974	U.S. sites reflective of the general population in the conterminous 48 states, FY 1972-FY 1974, lipid basis	Kutz, Strassman, and Yobs, 1976, 1977
Milk	1061 of 1436	GC-EC	1.0->116.0 ppb	95.8 ± 195.1 ppb	National study, fat basis	Savage, 1976
	57	GC-EC, GC/MS	Trace to 0.02 ppm	0.005 ppm	Selected areas of Mississippi and Arkansas, 1973-1974, 27% blacks, whole-milk basis	Strassman and Kutz, 1977

Table 64. Palladium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.0-0.1 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964
	300	AAS	NG	<0.9 µg/100 ml	Several locations in California, before auto catalysts	Johnson, Tillery, and Prevost, 1975a
Feces	300	AAS	NG	<0.001 µg/g	Before auto catalysts	Johnson, Tillery, and Prevost, 1975a
Hair	300	AAS	NG	<0.02 µg/g	Before auto catalysts	Johnson, Tillery, and Prevost, 1975a
Urine	300	AAS	NG	<0.30 µg/liter	Before auto catalysts	Johnson, Tillery, and Prevost, 1975a

Table 65. Pentachlorophenol

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	20	GC-EC	5.0-52.0 ppb	23.3 ppb	General population in Florida	Shafik, 1973
Blood	3568	NG	NG	0.5 ± 1.7 ppb	General population in Hawaii	Rashad et al., 1976
Urine	290	GC	0.0-1840 ppb	42.0 ppb	Values for occupationally exposed workers much higher	Bevenue et al., 1967
	NG	GC	2.3-31.2 ppb	2.2-10.8 ppb	General population	Crammer and Freal, 1970

Table 66. Platinum

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00–0.46 ppm	NG	39 healthy men, mean age 35.3 years, serum	Gofman et al., 1964
	300	AAS	<3.1 µg/100 ml	NG	Levels of platinum, palladium, and lead before auto catalysts, 150 subjects living near urban freeway, 150 in high desert area	Johnson, Tillery, and Prevost, 1975a
Feces	100	AAS	<0.002 µg/g	NG	Levels of platinum, palladium, and lead before auto catalysts, 150 subjects living near urban freeway, 150 in high desert area	Johnson, Tillery, and Prevost, 1975a
Hair	300	AAS	<0.05 µg/g	NG	Levels of platinum, palladium, and lead before auto catalysts, 150 subjects living near urban freeway, 150 in high desert area	Johnson, Tillery, and Prevost, 1975a
Urine	300	AAS	<0.6 µg/liter	NG	Levels of platinum, palladium, and lead before auto catalysts, 150 subjects living near urban freeway, 150 in high desert area	Johnson, Tillery, and Prevost, 1975a
21 various tissues	1313	ES	0.003–1.46 µg/g wet wt	0.16 µg/g wet wt	Before auto catalysts, California: 1313 samples from 97 autopsy sets. Of 1313 samples, 62 contained platinum, fat highest, none in lung, bones, hair	Duffield et al., 1976

Table 67. Polybrominated biphenyls

Tissue	Number of cases	Analytical method	Range	Mean level*	Comments	Reference
Adipose	15	GC	0.104-174 ppm	0.53 ppm (median)	Missouri dairy farm residents	Humphrey and Hayner, 1975
	111	NG	0.0-273.02 ppb	1965 ± 356 ppb	Exposed: quarantined farmers	Meester and McCoy, 1976
	116			516 ± 92 ppb	nonquarantined farmers	
				226 ± 73 ppb	Nonexposed: city residents	
				0.0 ppb	out-of-state visitors	
Blood	110	GC	0.0-2.26 ppm	0.014 ppm (median)	Missouri dairy farm residents, exposed: adults	Humphrey and Hayner, 1975
			0.002-2.26 ppm	0.035 ppm (median)	children	
	104	GC	0.0-0.09 ppm	0.003 ppm (median)	Missouri dairy farm residents, nonexposed: adults	Humphrey and Hayner, 1975
			0.002-0.09 ppm	0.006 ppm (median)	children	
	165	NG	0.0-2.26 ppm	<0.1 ppm (est.)	Farm families: exposed	Kay, 1977
	137				nonexposed	
	35 of 116	NG	0.1-28.6 ppb	NG	Higher values for quarantined farmers, serum	Meester and McCoy, 1976
Milk	6	GC	0.21-92.66 ppm	10.8 ppm	Missouri dairy farm residents	Humphrey and Hayner, 1975

Table 68. Polychlorinated biphenyls and polychlorinated terphenyls

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	2324	GC-EC, MS	Traces in 40%-50%, 1-2 ppm in 29%-35%, >2 ppm in about 5%	NG	Reflective of U.S. population in 48 conterminous states, FY 1973-FY 1974, lipid basis	Kutz and Strassman, 1976
	186	GC-EC	0.0->2.0 ppb	NG	Michigan general population, 98% contained trace to >2.0 ppm	Price and Welch, 1972
Blood	107	GC-EC	0.0-20.6 ppb	0.3 ppb	Rural blacks, South Carolina, plasma, PCB	Finklea et al., 1972
	151	GC-EC	0.0-29.0 ppb	1.9 ppb	Urban blacks, South Carolina, plasma, PCB	Finklea et al., 1972
	166	GC-EC	0.0-22.0 ppb	2.3 ppb	Urban white, South Carolina, plasma, PCB	Finklea et al., 1972
	192	GC-EC	0.0-16.6 ppb	3.1 ppb	Rural white, South Carolina, plasma, PCB	Finklea et al., 1972
	54	GC-EC	NG	3.7 ppb	Blood plasma, 11% positive but refuse workers 81%	Hammer et al., 1972
	NG	GC-EC	10-100 ppb	48 ppb	Whole blood, data on debilitated patients, none found in normals	Hesselberg and Scherr, 1974
Feces	32	GLC	NG	87.0 µg/day per person	Preadolescent females	Price, Young, and Dickinson, 1972
Hair	4	GC	0.34-0.76 ppm	NG	Excretory pathway	Matthews, Domanski, and Guthrie, 1976
Milk	39	GC-EC, TLC	0.04-1.00 ppm	0.05 ppm, fat basis	Eight positives of 39	Savage et al., 1973
	39	GC-EC	0.04-0.10 ppm	0.04 ppm, fat basis	Females, ages 19-33	Savage et al., 1972
	40	GC	40-100 ppb	9.75 ppb, fat basis	Rural county	Savage et al., 1973
	57	GC-EC, GC/MS	Trace	Trace	Selected areas of Arkansas and Mississippi, 1973-1974, 27% blacks, traces in all samples	Strassman and Kutz, 1977
Urine	32	GLC	NG	5.8 µg/day per person	Preadolescent females	Price, Young, and Dickinson, 1972

Table 69. Praseodymium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.0-0.13 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964
Teeth	56	MS	0.01-0.07 µg/g dry wt	0.027 µg/g dry wt	Subjects less than 20 years old, wide geographic area	Lowee, Cutress, and Brown, 1973

Table 70. Rhenium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.0-0.26 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964

Table 71. Rhodium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.0-0.16 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964

Table 72. Rubidium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood		NAA			10% higher for whites, Nashville, Tennessee:	Baglan et al., 1974
	712		NG	15.4 ± 3.2 µg/g dry wt	maternal blood	
	684		NG	17.8 ± 4.0 µg/g dry wt	infant blood	
	39	XRS	0.02-0.28 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964
	21	AAS			Normal Utah males:	Wood, 1969
			NG	4.18 ± 0.62 µg/ml	RBC	
			NG	0.16 ± 0.03 µg/ml	plasma	
	9	AAS			Males:	Wood, 1970
			NG	4.28 ± 0.75 µg/ml	RBC	
				0.18 ± 0.02 µg/ml	plasma	
	12				Females:	
			NG	4.10 ± 0.54 µg/ml	RBC	
				0.15 ± 0.02 µg/ml	plasma	
Hair	2	AAS, MS	NG	0.20 and 0.23 µg/g dry wt		Yurachek, Clemena, and Harrison, 1969
Placenta	826	NAA	NG	25.0 ± 5.8 µg/g dry wt	10% higher for whites, Nashville, Tennessee	Baglan et al., 1974
Teeth	56	MS	0.14-0.87 µg/g	0.41 µg/g	Subjects less than 20 years old, wide geographic area	Losee, Cutress, and Brown, 1973
Urine	21	AAS	NG	1.52 ± 0.55 µg/ml		Wood, 1969

Table 73. Ruthenium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.0-0.23 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964

Table 74. Samarium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00–0.18 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964

Table 75. Scandium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.0-0.3 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964
Hair	10	NAA	NG	0.0022 ± 0.00012 ppm	Hair cycle discussed	Obrusnik et al., 1972

Table 76. Selenium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	6	F	NG	0.04 ppm wet wt	Age, 9 months to 69 years	Schroeder, Frost, and Balassa, 1970
Blood	210	F	10-34 µg/100 ml	20.6 µg/100 ml	Blood bank donors	Allaway et al., 1968
	83	NAA	NG	1.10 ± 0.28 µg/g dry wt	Four large hospitals in Nashville, Tennessee, maternal blood	Baglan et al., 1974
	123	NAA	NG	1.04 ± 0.29 µg/g dry wt	Four large hospitals in Nashville, Tennessee, fetal blood	Baglan et al., 1974
	39	XRS	0.05-0.15 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964
	18	NAA	NG	1.49 ± 0.06 µg/g dry wt	VA hospital patients in Louisville, Kentucky, serum	McConnell et al., 1975
	10	F	17.0-27.3 µg/100 ml	21.71 ± 1.05 µg/100 ml	Normal persons, age 50-71 years	Shamberger et al., 1971
	12	F	13.7-21.1 µg/100 ml	16.2 ± 0.75 µg/100 ml	Cancer patients, age 50-71 years	Shamberger et al., 1971
	48	F	18-32 µg/100 ml	23.6 µg/100 ml 22.3 µg/100 ml	Cleveland area: 21 normal women 27 normal males	Shamberger et al., 1973
Bone	6	F	NG	0.42 ppm wet wt	Age, 9 months to 69 years	Schroeder, Frost, and Balassa, 1970
Brain	6	F	0.04-0.21 ppm wet wt	0.13 ppm wet wt	Age, 9 months to 69 years	Schroeder, Frost, and Balassa, 1970
Breast	6	F	NG	0.11 ppm wet wt	Age, 9 months to 69 years	Schroeder, Frost, and Balassa, 1970
Hair	33	NAA	1-11 ppm	6.4 ppm	Adults and children from Oak Ridge, Tennessee	Bate and Dyer, 1965
	260	AAS	0.025-1.65 µg/g	0.320 µg/g	Children from Queens, Riverhead, and Bronx	Creason et al., 1975
	188	AAS	0.025-1.58 µg/g	0.303 µg/g	Adults from Queens, Riverhead, and Bronx	Creason et al., 1975
	10	NAA	NG	0.720 ± 0.132 ppm		Obrusnik et al., 1972
Heart	6	F	0.25-0.37 ppm wet wt	0.28 ppm wet wt	Age, 9 months to 69 years	Schroeder, Frost, and Balassa, 1970

Table 76. Selenium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Intestine	6	F	0.12-0.32 ppm wet wt	0.21 ppm wet wt	Age, 9 months to 69 years, small intestine	Schroeder, Frost, and Balassa, 1970
Kidney	6	F	0.61-1.84 ppm wet wt	1.09 ppm wet wt	Age, 9 months to 69 years	Schroeder, Frost, and Balassa, 1970
Liver	7	NAA	NG	1.73 ± 0.24 µg/g dry wt	VA hospital patients in Louisville, Kentucky	McConnell et al., 1975
	6	F	0.28-0.81 ppm wet wt	0.54 ppm wet wt	Age, 9 months to 69 years	Schroeder, Frost, and Balassa, 1970
Lung	6	F	0.05-0.26 ppm wet wt	0.15 ppm wet wt	Age, 9 months to 69 years	Schroeder, Frost, and Balassa, 1970
Milk	241	F	0.007-0.060 ppm	0.018 ppm	Nursing mothers in or near cities, 27.4 ± 0.3 years, 183 ± 9 days postpartum	Shearer and Hadjimarkos,
	6	F	NG	0.24 ppm wet wt	Age, 9 months to 69 years	Schroeder, Frost, and Balassa, 1970
Muscle	6	F	0.11-0.38 ppm wet wt	0.24 ppm wet wt	Age, 9 months to 69 years	Schroeder, Frost, and Balassa, 1970
Pancreas	12	NAA	NG	0.63 ± 0.07 µg/g dry wt	VA hospital patients in Louisville, Kentucky	McConnell et al., 1975
	6	F	0.27-0.34 ppm wet wt	0.30 ppm wet wt	Age, 9 months to 69 years	Schroeder, Frost, and Balassa, 1970
Placenta	135	NAA	NG	1.04 ± 0.29 µg/g dry wt	Four large hospitals in Nashville, Tennessee	Baglan et al., 1974
	58	NG	NG	0.114 ± 0.005 µg/g wet wt	Southern and southeastern city hospitals	Karp and Robertson, 1977
Saliva	26	F	1.1-5.2 ppb	3.1 ppb	Children, ages 11-12, Oregon	Hadjimarkos and Shearer, 1972
Spleen	6	F	0.28-0.47 ppm wet wt	0.34 ppm wet wt	Age, 9 months to 69 years	Schroeder, Frost, and Balassa, 1970
Synovial membrane	28	NAA	NG	0.63 ± 0.12 µg/g dry wt	VA hospital patients in Louisville, Kentucky	McConnell et al., 1975
Teeth	56	MS	0.12-0.90 µg/g	0.43 ± 0.03 µg/g	Wide geographic area	Losee, Cutress, and Brown, 1973

Table 76. Selenium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Testis	6	F	0.15-0.38 ppm wet wt	0.30 ppm wet wt	Age, 9 months to 69 years	Schroeder, Frost, and Balassa, 1970
Urine	NG	NAA	NG	0.010 mg/liter		Gills et al., 1974
	13	Ch	0-15.9 µg/100 cc	5.0 ± 2.9 µg/100 cc 4.2 ± 1.8 µg/100 cc	Males, Rochester, New York: first morning specimens consecutive specimens for 24-hr period	Sterner and Lidfeldt, 1941

Table 77. Silicon

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	NG	NG	1000-5000 µg/liter	NG		Mertz, 1974
Hair	18	ES	0.03-0.36% dry wt	NG	Age, 15-70 years, white	Goldblum, Derby, and Lerner, 1953
	2	MS, AAS	10.9-27.9 µg/g dry wt	NG	Methodology	Yurachek, Clemena, and Harrison, 1969
Nails	18	ES	0.17-0.54% dry wt	NG	Age, 15-70 years, white	Goldblum, Derby, and Lerner, 1953
Skin	18	ES	0.64-2.14% dry wt	NG	Age, 15-70 years, white	Goldblum, Derby, and Lerner, 1953
Teeth	56	MS	100-450 µg/g	243 ± 18 µg/g	Wide geographic area	Losee, Cutress, and Brown, 1973
Urine	NG	NG	NG	15,000 µg/liter		Mertz, 1974

Table 78. Silver

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adrenal	10 of 13	ES	<0.1-3.2 µg/g ash	0.8 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Aorta	63 of 105	ES	<0.1-1.0 µg/g ash	0.1 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Bladder	46 of 112	ES	<0.1-0.7 µg/g ash	<0.1 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Blood	122	ES	NG	0.0004 ± 0.00003 mg/100 ml	Blood donors, Los Angeles area, serum	Butt et al., 1964
	96	ES	NG	0.0030 ± 0.0003 mg/100 ml	Surgical and degenerative disease patients, Los Angeles area, serum	Butt et al., 1964
	41	ES	NG	0.0013-0.0014 mg/100 ml	Normal persons, Los Angeles area, serum	Butt et al., 1964
	7	ES	NG	0.0024 ± 0.0003 mg/100 ml	Normal persons, Los Angeles area, whole blood	Butt et al., 1964
	39	XRS	0.02-0.38 ppm	NG	Healthy males, age 35.3 years, serum	Gofman et al., 1964
	NG	ES	NG	0.00+ mg/100 g		Kehoe, Cholak, and Story, 1940
	NG	NG	NG	0.03 µg/ml	Normal level	Rentoul and Smith, 1973
Bone	NG	ES	NG	0.00 mg/100 g wet wt	Long bone	Kehoe, Cholak, and Story, 1940
	NG	ES	NG	0.01 mg/100 g wet wt	Rib bone	Kehoe, Cholak, and Story, 1940
Brain	NG	ES	NG	0.003 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	3	ES	NG	0.033 mg/100 g dry wt		Nusbaum et al., 1958
	NG	NG	NG	0.03 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	113 of 128	ES	<0.1-1.6 µg/g ash	0.6 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Diaphragm	17 of 91	ES	<0.1-0.5 µg/g ash	<0.1 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Esophagus	32 of 68	ES	0.1-1.0 µg/g ash	<0.1 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Hair	33	NAA ES	0-12 ppm	3.8 ppm	Oak Ridge, Tennessee	Bate and Dyer, 1965
	266 198		0.007-6.20 µg/g 0.007-4.30 µg/g	0.205 µg/g 0.165 µg/g	Three New York communities: children adults	Creason et al., 1975

Table 78. Silver (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	18	ES	4.8×10^{-7}–4.5×10^{-6}% dry wt	NG	Age, 15–70 years, white	Goldblum, Derby, and Lerner, 1953
	10	NAA	NG	0.275 ± 0.038 ppm		Obrusnik et al., 1972
	NG	NG	NG	0.9 μ_b/g dry wt	Normal level	Rentoul and Smith, 1973
	2	MS, AAS	0.4–2.0 µg/g dry wt	NG	Methodology	Yurachek, Clemena, and Harrison, 1969
Heart	NG	ES	NG	0.00 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	3	ES	NG	0.026 mg/100 g dry wt		Nusbaum et al., 1958
	NG	NG	NG	0.01 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	31 of 138	ES	<0.1–0.5 µg/g ash	<0.1 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Intestine	NG	ES	NG	0.002 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
Duodenum	35 of 68	ES	<0.1–1.1 µg/g ash	0.1 µg/g ash (median)		Tipton and Cook, 1963
Jejunum	31 of 102	ES	<0.1–1.8 µg/g ash	0.1 µg/g ash (median)		Tipton and Cook, 1963
Ileum	49 of 84	ES	<0.1–1.1 µg/g ash	0.1 µg/g ash (median)		Tipton and Cook, 1963
Cecum	16 of 31	ES	<0.1–1.4 µg/g ash	0.1 µg/g ash (median)		Tipton and Cook, 1963
Sigmoid colon	64 of 109	ES	<0.1–2.0 µg/g ash	0.1 µg/g ash (median)		Tipton and Cook, 1963
Rectum	14 of 42	ES	<0.1–1.4 µg/g ash	<0.1 µg/g ash (median)		Tipton and Cook, 1963
Kidney	NG	ES	NG	0.00		Kehoe, Cholak, and Story, 1940
	3	ES	NG	0.026 mg/100 g dry wt		Nusbaum et al., 1958
	150	ES	<0.0009–0.0093 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	NG	NG	NG	0.005 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	67 of 143	ES	<0.1–1.0 µg/g ash	<0.1 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Larynx	20 of 50	ES	<0.1–0.5 µg/g ash	<0.1 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Liver	NG	ES	NG	0.005 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	3	ES	NG	0.034 mg/100 g dry wt		Nusbaum et al., 1958

Table 78. Silver (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	10	ES	NG	0.96 ± 0.88 μg/g ash	Five white and five black healthy males	Perry et al., 1973
	150	ES	0.0091-0.030 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	NG	NG	NG	0.04 μg/g dry wt	Normal level	Rentoul and Smith, 1973
	139 of 148	ES	0.1-3.2 μg/g ash	0.8 μg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Lung	NG	ES	NG	0.004 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	NG	ES	NG	0.030 mg/100 g dry wt		Nusbaum et al., 1958
	150	ES	<0.0009-0.0046 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1973
	54 of 139	ES	<0.1-12 μg/g ash	<0.1 μg/g ash (median)	Autopsy cases from nine cities	Tipton and Shafer, 1964
	54 of 139	ES	<0.1-0.5 μg/g ash	<0.1 μg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Muscle	NG	ES	NG	0.00 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	27 of 135	ES	<0.1-0.5 μg/g ash	<0.1 μg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Nails	18	ES	4.8×10^{-8}-6.5×10^{-7}% dry wt	NG	Age, 15-70 years, white	Goldblum, Derby, and Lerner, 1953
Omentum	61 of 74	ES	<0.1-1.5 μg/g ash	0.5 μg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Ovary	7 of 16	ES	<0.1-1.1 μg/g ash	<0.1 μg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Pancreas	61 of 137	ES	<0.1-1.0 μg/g ash	<0.1 μg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Placenta	58	NG	NG	ND at μg/g level	Southern and southeastern city hospitals	Karp and Robertson, 1977
Prostate	24 of 48	ES	<0.1-1.3 μg/g ash	<0.1 μg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Skin	18	ES	1.7×10^{-8}-4.5×10^{-8}% dry wt	NG	Age, 15-70 years, white	Goldblum, Derby, and Lerner, 1953
	21 of 22	ES	0.1-4.0 μg/g ash	1.3 μg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Spleen	NG	ES	NG	0.00 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	3	ES	NG	0.025 mg/100 g dry wt		Nusbaum et al., 1958

Table 78. Silver (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	44 of 141	ES	<0.1-0.5 µg/g ash	<0.1 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Stomach	NG	ES	NG	0.00 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	52 of 130	ES	<0.1-1.0 µg/g ash	<0.1 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Teeth	NG	NG	NG	1.0 ppm	Pueblo Indians, 800-year-old enamel	Anonymous, 1959
	208	MS			Subjects less than 20 years old:	Curzon and Losee, 1977
			NG	1.11 ± 1.04 ppm	high caries, New England	
			NG	7.43 ± 2.70 ppm	low caries, South Carolina	
	56	MS	0.01-0.77 µg/g dry wt	0.140 µg/g dry wt	Wide geographic area	Losee, Cutress, and Brown, 1973
Testis	24 of 71	ES	<0.1-0.5 µg/g ash	<0.1 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Thyroid	10 of 20	ES	<0.1-9.8 µg/g ash	<0.1 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Trachea	32 of 60	ES	<0.1-1.3 µg/g ash	<0.1 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Urine	NG	ES	NG	0.00 mg/liter		Kehoe, Cholak, and Story, 1940
	24	ES	0.42-3.8 µg/liter	1.50-1.67 µg/liter	10 black and 14 white persons, age 4-69 years, St. Louis, Missouri	Perry and Perry, 1959
Uterus	10 of 32	ES	<0.1-0.6 µg/g ash	<0.1 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963

Table 79. Strontium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adrenal	13	ES	0.8-9.5 µg/g ash	3.5 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Aorta	100	ES	0.12-0.87 micromole/g ash	NG		Perry, 1968
	150	ES	0.17-0.89 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	103	ES	15-78 µg/g ash	33 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Blood	122	ES	NG	0.0153 ± 0.0008 mg/100 ml	Blood donors in Los Angeles area, serum	Butt et al., 1964
	96	ES	NG	0.0040 ± 0.0005 mg/100 ml	Hospital patients in Los Angeles area, serum	Butt et al., 1964
	48	ES	NG	0.0046 ± 0.0003 mg/100 ml	Normal persons in Los Angeles area, serum	Butt et al., 1964
	47	ES	NG	0.0039 ± 0.0002 mg/100 ml	Normal persons in Los Angeles area, whole blood	Butt et al., 1964
	39	XRS	0.00-0.05 ppm	NG	39 healthy men, mean age 35.3 years, serum	Gofman et al., 1964
Bone	2	ES	30-80 ppm	NG	Skeleton, white male, age 60, skeleton, black male, age 48	Forbes, Mitchell, and Cooper, 1956
	38	ES	NG	0.011% ash 0.019% ash	Fetal Other samples	Nusbaum et al., 1958
	5	AAS	NG	0.57 mg/g calcium	Fetal	Rosenthal, Cochran, and Eves, 1972
	3	AAS	NG	38.91 ± 0.76 mg/g calcium	Adult	Rosenthal, Cochran, and Eves, 1972
	35	NG	<0.1-3.4 µµCi/g calcium	NG	Alaska, ages 4 months to 62 years	Schulert, 1962
	35	NAA	41.6-157 ppm	79.1 ± 20 ppm 73.8 ± 26 ppm 107 ± 23 ppm 114 ± 28 ppm	Males and females: 0-3 months 1-13 years 19-33 years 33-74 years	Sowden and Stitch, 1957
Brain	100	ES	0.0064-0.096 micromole/g ash	NG		Perry, 1968
	150	ES	0.0057-0.049 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962

Table 79. Strontium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	127	ES	0.5-4.3 µg/g ash	1.14 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Diaphragm	91	ES	1.4-7.8 µg/g ash	3.3 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Esophagus	65	ES	4.3-17 µg/g ash	8.2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Feces	2	ES	NG	1.7 ± 0.2 mg/day 2.1 ± 0.2 mg/day	Healthy 23- and 25-year-old men, University of Cincinnati	Tipton, Stewart, and Dickson, 1969
Hair	18	ES	2.2×10^{-6}-9.1×10^{-6}% dry wt	NG	White males, 15-70 years old	Goldblum, Derby, and Lerner, 1953
	7	R	11-22 pCi/g calcium	15 pCi/g calcium	Boston and New Orleans	Moeller, Baratta, and Leonard, 1964
	2	R	NG	9.5 pCi/g calcium	Phoenix	Moeller, Baratta, and Leonard, 1964
	2	MS	NG	1.1 µg/g dry wt 0.75 µg/g dry wt	Methodology	Yurachek, Clemena, and Harrison, 1969
Heart	100	ES	0.014-0.19 micromole/g ash	NG		Perry, 1968
	150	ES	0.012-0.081 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	140	ES	1.1-7.1 µg/g ash	2.6 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Intestine						
Duodenum	67	ES	2.4-25 µg/g ash	11 µg/g ash (median)		Tipton and Cook, 1963
Jejunum	100	ES	3.1-33 µg/g ash	11 µg/g ash (median)		Tipton and Cook, 1963
Ileum	81	ES	6.0-62 µg/g ash	25 µg/g ash (median)		Tipton and Cook, 1963
Cecum	31	ES	11-100 µg/g ash	42 µg/g ash (median)		Tipton and Cook, 1963
Sigmoid colon	107	ES	5.5-76 µg/g ash	23 µg/g ash (median)		Tipton and Cook, 1963
Rectum	42	ES	5.2-57 µg/g ash	26 µg/g ash (median)		Tipton and Cook, 1963
Kidney	100	ES	0.047-0.16 micromole/g ash	NG		Perry, 1968
	150	ES	0.033-0.14 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	143	ES	2.8-12 µg/g ash	5.2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963

Table 79. Strontium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Larynx	50	ES	10-70 µg/g ash	25 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Liver	2	ES	0	ND at ppm level	White male, age 60, and black male, age 48	Forbes, Mitchell, and Cooper, 1956
	10	ES	NG	1.70 ± 1.16 µg/g ash	Five white males, five black males, accident victims in St. Louis	Perry et al., 1973
	100	ES	0.018-0.075 micromole/g ash	NG		Perry, 1968
	150	ES	0.008-0.040 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	146	ES	0.7-3.5 µg/g ash	1.6 µg/g ash	U.S. tissues	Tipton and Cook, 1963
Lung	2	ES	0	ND at ppm level	White male, age 60, and black male, age 48	Forbes, Mitchell, and Cooper, 1956
	100	ES	0.073-0.16 micromole/g ash	NG		Perry, 1968
	150	ES	0.050-0.19 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	168	NG	5-460 µg	NG	Samples from 58 cities and 29 nonurban areas, total lung content	Schroeder, 1970b
	141	ES	4.5-17 µg/g ash	8.2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
	141	ES	0.5-46 µg/g ash	9.8 µg/g ash	Autopsy cases, nine U.S. cities	Tipton and Shafer, 1964
Milk	5	R	0.80-2.44% ingested 0.19 ± 0.5 to 0.50 ± 0.10 µµCi/kg milk	NG	Women, ages 17-22, Ithaca, New York, fed controlled diet	Lough, Hamada, and Comar, 1960
Muscle	2	ES	0	ND at ppm level	White male, age 60, and black male, age 48, striated muscle	Forbes, Mitchell, and Cooper, 1956
	135	ES	0.3-4.0 µg/g ash	1.2 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Nails	18	ES	1.6×10^{-7}-3.3×10^{-6}% dry tissue	NG	White males, 15-70 years old	Goldblum, Derby, and Lerner, 1953
Omentum	74	ES	3.6-25 µg/g ash	9.5 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Ovary	16	ES	4.0-33 µg/g ash	11 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963

Table 79. Strontium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Pancreas	139	ES	1.5-9.5 μg/g ash	3.3 μg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Prostate	48	ES	5.0-48 μg/g ash	11 μg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Skin	18	ES	3.2×10^{-9}-4.5×10^{-9}% dry tissue	NG	White males, 15-70 years old	Goldblum, Derby, and Lerner, 1953
	21	ES	4.5-15 μg/g ash	8.6 μg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Spleen	100	ES	0.013-0.11 micromole/g ash	NG		Perry, 1968
	150	ES	0.012-0.068 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	143	ES	1.1-6.0 μg/g ash	2.1 μg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Stomach	130	ES	3.4-28 μg/g ash	9.9 μg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Teeth	35	AAS	26-132 ppm	67 ± 20 ppm	9- to 15-year-old school children in Cambridge, Massachusetts	Brudevold et al., 1975
	15	AAS	69-148 ppm	91 ± 21 ppm	9- to 15-year-old school children in Cambridge, Massachusetts	Brudevold et al., 1975
	208	MS			Subjects less than 20 years old:	Curzon and Losee, 1977
			NG	128.9 ± 8.39 ppm	New England, enamel	
			NG	156.7 ± 10.87 ppm	South Carolina, enamel	
	208	MS			Subjects less than 20 years old, combined areas of New England and South Carolina:	Curzon and Losee, 1977
			NG	104.1 ± 9.14 ppm	high caries	
			NG	184.0 ± 14.68 ppm	low caries	
	87	MS	384-649.3 ppm	NG	Surface enamel, subjects 12-14 years old, Oregon, Montana, and California	Little and Barrett, 1976
	87	MS	313-555 ppm	NG	Subsurface enamel, subjects 12-14 years old, Oregon, Montana, and California	Little and Barrett, 1976
	87	MS	281.8-490.1 ppm	NG	Inner enamel, subjects 12-14 years old, Oregon, Montana, and California	Little and Barrett, 1976

Table 79. Strontium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	87	MS	64.6-266 ppm	NG	Bulk enamel, subjects 12-14 years old, Oregon, Montana, and California	Little and Barrett, 1976
	56	MS	21-280 µg/g	121 ± 11 µg/g	Subjects less than 20 years old	Losee, Cutress, and Brown, 1973
	41	NG	1.73-2.79 pCi/g calcium	NG	Children in St. Louis born between 1950 and 1958	Rosenthal et al., 1964
	30	NG	1.72-3.54 pCi/g calcium	NG	7- to 9-month-old fetuses, St. Louis	Rosenthal et al., 1964
	18	AAS	0.31-0.61 mg/g calcium	NG		Rosenthal, Cochran, and Eves, 1972
Testis	69	ES	1.9-13 µg/g ash	4.3 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Thyroid	21	ES	5.3-21 µg/g ash	13 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Total body content	168	NG		320 mg	Samples from 58 cities and 29 nonurban areas	Schroeder, 1970*b*
Urinary bladder	110	ES	5.5-23 µg/g ash	12 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Urine	6	NG	NG	25.0 µµCi/g calcium	Alaska	Schulert, 1962
	2	ES	NG	0.12 ± 0.01 mg/day 0.10 ± 0.01 mg/day	Healthy 23- and 25-year-old men, University of Cincinnati	Tipton, Stewart, and Dickson, 1969
Uterus	32	ES	2.3-21 µg/g ash	9.5 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963

Table 80. Tantalum

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00–0.41 ppm	NG	Healthy men, mean age 35.3 years, serum	Gofman et al., 1964

Table 81. Tellurium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	NG	NAA	NG	1.8 µg/g wet wt		Schroeder, Buckman, and Balassa, 1967
Blood	39	XRS	0.00-0.049 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964
	10	NG	0.5-1.6 µg/ml	1.07 ± 0.12 µg/ml	Serum	Schroeder, Buckman, and Balassa, 1967
	2	NG	NG	1.30 ± 1.95 µg/ml	Red blood cells	
Bone	NG	NAA	NG	77.0 µg/g wet wt	Natural cycle: soil to plants to animals; some industrial contamination	Schroeder, Buckman, and Balassa, 1967
Brain	4	AAS	NG	1.88 µg/g wet wt	Natural cycle: soil to plants to animals; some industrial contamination	Schroeder, Buckman, and Balassa, 1967
Heart	4	AAS	NG	0.83 µg/g wet wt	Natural cycle: soil to plants to animals; some industrial contamination	Schroeder, Buckman, and Balassa, 1967
Kidney	4	AAS	NG	0.88 µg/g wet wt	Natural cycle: soil to plants to animals; some industrial contamination	Schroeder, Buckman, and Balassa, 1967
Liver	3	AAS	4.36-8.27 µg/g wet wt	NG	Natural cycle: soil to plants to animals; some industrial contamination	Schroeder, Buckman, and Balassa, 1967
Lung	3	AAS	0.12-0.99 µg/g wet wt	NG	Natural cycle: soil to plants to animals; some industrial contamination	Schroeder, Buckman, and Balassa, 1967
Muscle	2	AAS	0.35-0.63 µg/g wet wt	NG	Natural cycle: soil to plants to animals; some industrial contamination	Schroeder, Buckman, and Balassa, 1967
Ovary	NG	NAA	NG	0.14 µg/g wet wt	Natural cycle: soil to plants to animals; some industrial contamination	Schroeder, Buckman, and Balassa, 1967
Pancreas	3	AAS	NG	1.06 µg/g wet wt	Natural cycle: soil to plants to animals; some industrial contamination	Schroeder, Buckman, and Balassa, 1967

Table 81. Tellurium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Spleen	NG	NAA	1.01-1.86 µg/g wet wt	NG	Natural cycle: soil to plants to animals; some industrial contamination	Schroeder, Buckman, and Balassa, 1967
Testis	NG	NAA	NG	0.38 µg/g wet wt	Natural cycle: soil to plants to animals; some industrial contamination	Schroeder, Buckman, and Balassa, 1967
Urine	NG	NG	0.26-1.09 µg/ml	NG	Natural cycle: soil to plants to animals; some industrial contamination	Schroeder, Buckman, and Balassa, 1967

Table 82. Terbium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00–0.23 ppm	NG	Healthy men, mean age 35.3 years, serum	Gofman et al., 1964

Table 81. Thallium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00-0.03 ppm	NG	Healthy men, mean age 35.3 years, serum	Gofman et al., 1964
	NG	NG	NG	0.02 µg/ml	Normal values	Rentoul and Smith, 1973
	320	AAS	0.0-8.0 µg/100 ml	0.3 µg/100 ml	Children, age 1-5 years, predominantly black and Spanish-speaking residents of Newark, New Jersey, whole blood	Singh, Bogden, and Joselow, 1975
Brain	NG	NG	NG	0.5 µg/g dry wt	Normal values	Rentoul and Smith, 1973
Heart	NG	NG	NG	0.4 µg/g dry wt	Normal values	Rentoul and Smith, 1973
Kidney	NG	NG	NG	0.4 µg/g dry wt	Normal values	Rentoul and Smith, 1973
Liver	NG	NG	NG	0.4 µg/g dry wt	Normal values	Rentoul and Smith, 1973

Table 84. Thorium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00-0.10 ppm	NG	Healthy men, mean age 35.3 years, serum	Gofman et al., 1964

Table 85. Thulium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00-0.36 ppm	NG	Healthy men, mean age 35.3 years, serum	Gotman et al., 1964

Table 86. Tin

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adrenal	14 of 15	ES	5-72 µg/g ash	23 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Aorta	100	ES	<0.04-0.21 micromole/g dry wt	NG		Perry, 1968
	150	ES	0.042-0.32 micromole/g ash	NG		Perry et al., 1962
	96 of 105	ES	5-38 µg/g ash	14 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Bladder	2	ES	NG	5.2 ppm wet wt	Sudden accident victims, male, up to 56 years old	Koch et al., 1956
	100 of 112	ES	<5-58 µg/g ash	16 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Blood	39	XRS	0.00-0.47 ppm	NG	Healthy men, mean age 35.3 years, serum	Gofman et al., 1964
	NG	ES	NG	0.012 mg/100 g		Kehoe, Cholak, and Story, 1940
	NG	NG	NG	140 µg/ml		Hertz, 1974
	NG	NG	NG	0.12 µg/ml		Rentoul and Smith, 1973
Bone	NG	ES	NG	0.080 mg/100 g wet wt 0.050 mg/100 g wet wt	Long bone Rib bone	Kehoe, Cholak, and Story, 1940
	2	ES	NG	0.3 ppm wet wt	Sudden accident victims, male, up to 56 years old	Koch et al., 1956
Brain	NG	ES	NG	0.0 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	3	ES	NG	1.0 ppm wet wt	Sudden accident victims, male, up to 56 years old	Koch et al., 1956
	NG	NG	NG	2 µg/g dry wt	Normal values	Rentoul and Smith, 1973
	7 of 129	ES	<5-<5 µg/g ash	<5 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Diaphragm	55 of 91	ES	<5-29 µg/g ash	5 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Esophagus	1	ES	NG	0.3 ppm wet wt	Sudden accident victims, male, up to 56 years old	Koch et al., 1956
	58 of 68	ES	<5-62 µg/g ash	18 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Feces	2	ES	NG	3.6 ± 0.7 mg/day 3.6 ± 0.5 mg/day	Healthy 23- and 25-year-old men, University of Cincinnati	Tipton, Stewart, and Dickson, 1969

Table 86. Tin (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Hair	265	ES	0.034-8.30 µg/g	0.561 µg/g	Children from Riverhead, Queens, and Bronx	Creason et al., 1975
	191	ES	0.048-12.00 µg/g	0.785 µg/g	Adults from Riverhead, Queens, and Bronx	Creason et al., 1975
		ES			Children:	Creason et al., 1975
	126		NG	0.54 µg/g	Riverhead	
	90			0.44 µg/g	Queens	
	71			0.83 µg/g	Bronx	
	2	MS	NG	0.4 µg/g dry wt 0.39 µg/g dry wt	Methodology	Yurachek, Clemena, and Harrison, 1969
Heart	NG	ES	NG	0.022 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	100	ES	<0.04-0.13	NG		Perry, 1968
	NG	NG	NG	0.2 µg/g dry wt	Normal values	Rentoul and Smith, 1973
	84 of 140	ES	<5-27 µg/g ash	5 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
	150	ES	<0.04-0.23 micromole/g ash	NG		Perry et al., 1962
Intestine	NG	ES	NG	0.016 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
Large intestine	1	ES	NG	0.2 ppm wet wt	Sudden accident victims, male, up to 56 years old	Koch et al., 1956
Small intestine	7	ES	NG	0.4 ppm wet wt	Sudden accident victims, male, up to 56 years old	Koch et al., 1956
Duodenum	61 of 68	ES	<5-160 µg/g ash	28 µg/g ash (median)		Tipton and Cook, 1963
Jejunum	100 of 104	ES	8-110 µg/g ash	36 µg/g ash (median)		Tipton and Cook, 1963
Ileum	80 of 84	ES	15-430 µg/g ash	79 µg/g ash (median)		Tipton and Cook, 1963
Cecum	31	ES	45-800 µg/g ash	130 µg/g ash (median)		Tipton and Cook, 1963
Sigmoid colon	107 of 109	ES	10-330 µg/g ash	45 µg/g ash (median)		Tipton and Cook, 1963
Rectum	39 of 42	ES	5-180 µg/g ash	57 µg/g ash (median)		Tipton and Cook, 1963
Kidney	NG	ES	NG	0.020 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	6	ES	NG	0.4 ppm wet wt	Sudden accident victims, male, up to 56 years old	Koch et al., 1956

Table 86. Tin (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	6	ES	0.9-7.8 µg/g dry wt	2.8 µg/g dry wt		Koch, Smith, and McNelly, 1957
	2	ES	1.1-6.0 µg/g dry wt	NG		Koch, Smith, and McNelly, 1957
	100	ES	<0.04-0 micromole/g wt	NG		Perry, 1968
	150	ES	0.042-0.39 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	NG	NG	NG	0.2 µg/g dry wt	Normal values	Rentoul and Smith, 1973
	161	ES	<5-480 ppm ash	30 ppm ash		Schroeder, Balassa, and Tipton, 1964
	NG	ES	0-1.5+ mg/100 g dry wt	NG	Cancer patients	Tietz, Hirsch, and Neyman, 1957
	140 of 145	ES	5-46 µg/g ash	16 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Larynx	34 of 50	ES	<5-16 µg/g ash	8 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Liver	NG	ES	NG	0.060 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	5	ES	NG	2.5 ppm wet wt	Sudden accident victims, male, up to 56 years old	Koch et al., 1956
	5	ES	3.2-21.1 µg/g dry wt	12.0 µg/g dry wt		Koch, Smith, and McNelly, 1957
	3	ES	1.4-3.2 µg/g dry wt	NG		Koch, Smith, and McNelly, 1957
	100	ES	<0.04-0.24 micromole/g dry wt	NG		Perry, 1968
	10	ES	NG	37.50 ± 16.4 µg/g tissue ash	Healthy adult males from St. Louis, accident victims	Perry et al., 1973
	150	ES	0.041-0.62 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	NG	NG	NG	0.6 µg/g dry wt	Normal values	Rentoul and Smith, 1973
	163	ES	<5-300 ppm ash	35 ppm ash		Schroeder, Balassa, and Tipton, 1964
	NG	ES	0-1.5+ mg/100 g dry wt	NG	Cancer patients	Tietz, Hirsch, and Neyman, 1957
	144 of 150	ES	5-74 µg/g ash	23 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963

Table 86. Tin (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Lung	NG	ES	NG	0.045 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	4	ES	NG	3.8 ppm wet wt	Sudden accident victims, male, up to 56 years old	Koch et al., 1956
	4	ES	1.6-49.1 µg/g dry wt	22.4 µg/g dry wt	Normal subjects	Koch, Smith, and McNelly, 1957
	5	ES	0.8-14.7 µg/g dry wt	NG	Patients with lymphomatous diseases	Koch, Smith, and McNelly, 1957
	100	ES	<0.04-0.62 micromole/g dry wt	NG		Perry, 1968
	150	ES	0.093-0.93 micromole/g ash	NG	Adults who died unexpectedly, St. Louis	Perry et al., 1962
	159	ES	<5-920 ppm ash	69 ppm ash		Schroeder, Balassa, and Tipton, 1964
	168	NG		17 µg/g ash	Samples from 58 cities and 29 nonurban areas, amount retained in lungs	Schroeder, 1970*b*
	168	NG		Max — 9200 µg, min — 200 µg	Samples from 58 cities and 29 nonurban areas	Schroeder, 1970*b*
	NG	ES	NG	0-3.0 mg/100 g dry wt	Cancer patients	Tietz, Hirsch, and Neyman, 1957
	137 of 140	ES	11-110 µg/g ash	37 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
	141	ES	<5-920 µg/g ash	37 µg/g ash (median)	Autopsy cases, nine U.S. cities	Tipton and Shafer, 1964
Muscle	NG	ES	NG	0.011 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	8	ES	NG	0.7 ppm wet wt	Sudden accident victims, male, up to 56 years old	Koch et al., 1956
	26 of 137	ES	<5-10 µg/g ash	<5 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Omentum	69 of 74	ES	5-48 µg/g ash	16 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Ovary	13 of 16	ES	<5-210 µg/g ash	15 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Pancreas	2	ES	NG	1.0 ppm wet wt	Sudden accident victims, male, up to 56 years old	Koch et al., 1956
	73 of 169	ES	<5-24 µg/g ash	5 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963

Table 86. Tin (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Placenta	58	NG	NG	0.003 ± 0.003 µg/g wet wt	Southern and southeastern city hospitals	Karp and Robertson, 1977
Prostate	4	ES	NG	1.5 ppm wet wt	Sudden accident victims, male, up to 56 years old	Koch et al., 1956
	42 of 50	ES	<5-39 µg/g ash	14 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Skin	21 of 22	ES	7-74 µg/g ash	21 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Spleen	NG	ES	NG	0.022 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	3	ES	NG	0.6 ppm wet wt	Sudden accident victims, male, up to 56 years old	Koch et al., 1956
	3	ES	1.0-4.3 µg/g dry wt	3.2 µg/g dry wt	Normal subjects	Koch, Smith, and McNelly, 1957
	2	ES	0.9-5.1 µg/g dry wt	NG	Patients with lymphomatous diseases	Koch, Smith, and McNelly, 1957
	100	ES	<0.04-0.11 micromole/g dry wt	NG		Perry, 1968
	150	ES	<0.04-0.29 micromole/g ash	NG		Perry et al., 1962
	120 of 143	ES	<5-35 µg/g ash	11 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Stomach	NG	ES	NG	0.050 mg/100 g wet wt		Kehoe, Cholak, and Story, 1940
	3	ES	NG	0.4 ppm wet wt	Sudden accident victims, male, up to 56 years old	Koch et al., 1956
	111 of 131	ES	<5-74 µg/g ash	16 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Teeth	208	MS			Enamel, subjects less than 20 years old:	Curzon and Losee, 1977
			NG	0.24 ± 0.08 ppm	high caries area, New England	
				1.35 ± 0.37 ppm	low caries area, South Carolina	
	56	MS	0.03-7.10 µg/g dry wt	0.53 ± 0.14 µg/g dry wt	Less than 20 years old	Losee, Cutress, and Brown, 1973
	NG	NG	NG	1.0 ppm	External enamel from Pueblo Indians, 800 years old	Anonymous, 1959

Table 86. Tin (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Testis	54 of 72	ES	<5-33 µg/g ash	11 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Thyroid	2	ES	NG	0.2 ppm wet wt	Sudden accident victims, male, up to 56 years old	Koch et al., 1956
	16 of 21	ES	<5-47 µg/g ash	13 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Total body content	168	NG	NG	17 mg	Samples from 58 cities and 29 nonurban areas	Schroeder, 1970*b*
Trachea	54 of 60	ES	<5-50 µg/g ash	12 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Urine	NG	ES	NG	0.011 mg/liter		Kehoe, Cholak, and Story, 1940
	NG	NG	10-20 µg/ml	NG		Hertz, 1974
	15	ES	NG	Approximately 3 ppb	Normal subjects	Perry, 1968
	15			Approximately 7 ppb	Hypertensive	
	8			Approximately 4.3 ppb	Hypertensive, treated	
	7			Approximately 7 ppb	Hypertensive, untreated	
	24	ES	3.0-4.0 µg/liter	16.6 µg/liter	Normal, ages 4-69 years	Perry and Perry, 1969
	10		NG	16.4 µg/liter	Normal females	
	14		NG	16.8 µg/liter	Normal males	
	10		NG	17.9 µg/liter	Normal Negroes	
	14		NG	15.8 µg/liter	Normal Caucasians	
	8		NG	20.6 µg/liter	Hypercholesterolemic patients before Na_2Ca EDTA administration	
	8		NG	14.8 µg/liter	Hypercholesterolemic patients during Na_2Ca EDTA administration	
	4		NG	21.6 µg/liter	Hypercholesterolemic patients one day after Na_2Ca EDTA administration	
	3		NG	23.2 µg/liter	Hypercholesterolemic patients two days after Na_2Ca EDTA administration	
	NG	NG	NG	0.01 µg/liter	Normal values	Rentoul and Smith, 1973
	2	ES	NG	0.085 ± 0.011 mg/day 0.058 ± 0.006 mg/day	Healthy 23- and 25-year-old men, University of Cincinnati	Tipton, Stewart, and Dickson, 1969
Uterus	24 of 32	ES	<5-65 µg/g ash	10 µg/g ash (median)	U.S. tissues	Tipton and Cook, 1963
Vena cava	1	ES	NG	NG	Sudden accident victims, male, up to 56 years old	Koch et al., 1956

Table 87. Titanium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adrenal	8 of 13	ES	<5-45 µg/g ash	15 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Aorta	100	ES	<0.1-2.3 micromoles/g ash	NG	10th and 90th percentiles	Perry, 1968
	150	ES	<0.1-0.52 micromole/g ash	NG	Adult St. Louis area residents, unexpected deaths, less than 50% of the values, 10th and 90th percentiles	Perry et al., 1962
	45 of 104	ES	<5-25 µg/g ash	<5 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Bladder	43 of 110	ES	<5-29 µg/g ash	<5 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Blood	39	XRS	0.00-0.18 ppm	NG	Healthy males, mean age 35.3 years, serum	Gofman et al., 1964
Brain	100	ES	<0.1-0.42 micromole/g ash	NG	10th and 90th percentiles	Perry, 1968
	12 of 129	ES	<5-<5 µg/g ash	<5 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Diaphragm	33 of 91	ES	<5-14 µg/g ash	<5 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Esophagus	32 of 66	ES	<5-44 µg/g ash	<5 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Feces	2	ES	0.46 ± 0.09 mg/day 0.82 ± 0.20 mg/day	NG	Healthy 23- and 25-year-old males	Tipton, Stewart, and Dickson, 1969
Hair	18	ES	0.0000032-0.0000064% dry tissue	NG	White males, 15-70 years old	Goldblum, Derby, and Lerner, 1953
	2	MS	3.9 and 24.0 µg/g dry wt	NG	Methodology	Yurachek, Clemena, and Harrison, 1969
Heart	100	ES	<0.1-5.2 micromoles/g ash	NG	10th and 90th percentiles	Perry, 1968
	150	ES	<0.1-0.10 micromole/g ash	NG	Adult St. Louis area residents, unexpected deaths, less than 50% of the values, 10th and 90th percentiles	Perry et al., 1962
	24 of 140	ES	<5-5 µg/g ash	<5 µg/g ash (median)	Adults	Tipton and Cook, 1963

Table 87. Titanium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Intestine						
Small intestine	1	ES	NG	5.2 ppm wet wt	Male sudden accident victim	Koch et al., 1956
Duodenum	25 of 67	ES	<5-23 µg/g ash	<5 µg/g ash (median)	Adult	Tipton and Cook, 1963
Jejunum	15 of 102	ES	<5-5 µg/g ash	<5 µg/g ash (median)	Adult	Tipton and Cook, 1963
Ileum	36 of 84	ES	<5-21 µg/g ash	<5 µg/g ash (median)	Adult	Tipton and Cook, 1963
Cecum	16 of 31	ES	<5-11 µg/g ash	<5 µg/g ash (median)	Adult	Tipton and Cook, 1963
Sigmoid colon	36 of 108	ES	5-33 µg/g ash	<5 µg/g ash (median)	Adult	Tipton and Cook, 1963
Rectum	22 of 42	ES	<5-16 µg/g ash	5 µg/g ash (median)	Adult	Tipton and Cook, 1963
Kidney	1	ES	NG	1.2 ppm wet wt	Male sudden accident victims	Koch et al., 1956
	100	ES	<0.1-0.84 micromole/g ash	NG	10th and 90th percentiles	Perry, 1968
	150	ES	<0.1-0.12 micromole/g ash	NG	Adult St. Louis area residents, unexpected deaths, less than 50% of the values, 10th and 90th percentiles	Perry et al., 1962
	168	ES	Trace to 0.67 µg/g ash wet wt	NG	Urban area autopsies	Schroeder, Balassa, and Tipton, 1963a
	22 of 144	ES	<5-5 µg/g ash	<5 µg/g ash (median)	Adults	Tipton and Cook, 1963
Larnyx	11 of 50	ES	<5-10 µg/g ash	<5 µg/g ash (median)	Adults	Tipton and Cook, 1963
Liver	1	ES	NG	3.0 ppm wet wt	Male sudden accident victims	Koch et al., 1956
	100	ES	<0.1-0.49 micromole/g ash	NG	10th and 90th percentiles	Perry, 1968
	10	ES	NG	15.20 ± 16.20 µg/g ash	Healthy adult males, St. Louis area residents, five Caucasians and five Negroes, accident victims	Perry et al., 1973
	150	ES	<1-0.33 micromoles/g ash	NG	Adult St. Louis area residents, unexpected deaths, less than 50% of the values, 10th and 90th percentiles	Perry et al., 1962

Table 87. Titanium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	168	ES	Trace to 0.50 µg/g wet wt	NG	Urban area autopsies	Schroeder, Balassa, and Tipton, 1963
	34 of 148	ES	<5-16 µg/g ash	<5 µg/g ash (median)	Adult	Tipton and Cook, 1963
Lung	2	ES	NG	3.2 ppm wet wt	Male sudden accident victim	Koch et al., 1956
	100	ES	0.72-21 micromoles/g ash	NG	10th and 90th percentiles	Perry, 1968
	150	ES	1-15 micromoles/g ash	NG	Adult St. Louis area residents, unexpected deaths, 10th and 90th percentiles	Perry et al., 1962
	168 samples	NG	<50->700 µg/g	87 µg/g	58 urban and 29 nonurban autopsies	Schroeder, 1970b
	168	ES	2.4-7.7 µg/g wet wt	NG	Urban area autopsies	Schroeder, Balassa, and Tipton, 1963
	141	ES	<5->2000 µg/g ash	220 µg/g ash (median)	Urban area autopsies	Tipton and Shafer, 1964
	139 of 141	ES	55-700 µg/g ash	220 µg/g ash (median)	Adults	Tipton and Cook, 1963
Muscle	1	ES	NG	2.2 ppm wet wt	Male sudden accident victim	Koch et al., 1956
	17 of 136	ES	<5-5 µg/g ash	<5 µg/g ash (median)	Adults	Tipton and Cook, 1963
Nails	18	ES	0.0000163-0.000039% dry tissue	NG	White males, 15-70 years old	Goldblum, Derby, and Lerner, 1953
Omentum	67 of 75	ES	<5-74 µg/g ash	21 µg/g ash (median)	Adults	Tipton and Cook, 1963
Ovary	6 of 16	ES	<5-13 µg/g ash	<5 µg/g ash (median)	Adults	Tipton and Cook, 1963
Pancreas	29 of 139	ES	<5-16 µg/g ash	<5 µg/g ash (median)	Adults	Tipton and Cook, 1963
Prostate	1	ES	NG	11 ppm wet wt	Male sudden accident victims	Koch et al., 1956
	16 of 50	ES	<5-33 µg/g ash	<5 µg/g ash (median)	Adults	Tipton and Cook, 1963
Skin	18	ES	0.000106-0.000277% dry wt	NG	White males, 15-70 years old	Goldblum, Derby, and Lerner, 1953
	22	ES	17-100 µg/g ash	32 µg/g ash (median)	Adults	Tipton and Cook, 1963
Spleen	100	ES	<0.1-0.59 micromole/g ash	NG	10th and 90th percentiles	Perry, 1968
	150	ES	<0.1-0.29 micromole/g ash	NG	Adult St. Louis area residents, unexpected deaths, less than 50% of the values, 10th and 90th percentiles	Perry et al., 1962

Table 87. Titanium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	168	ES	Trace to 1.0 ppm wet wt	NG	Urban area autopsies	Schroeder, Balassa, and Tipton, 1960
	31 of 143	ES	<5-14 µg/g ash	<5 µg/g ash (median)	Adults	Tipton and Cook, 1963
Stomach	1	ES	NG	6.6 ppm wet wt	Male sudden accident victim	Koch et al., 1956
	26 of 130	ES	<5-5 µg/g ash	<5 µg/g ash (median)	Adults	Tipton and Cook, 1963
Teeth	56	MS	<0.1-4.80 µg/g dry wt	0.46 ± 0.13 µg/g dry wt	Subjects less than 20 years old, wide geographic area, enamel	Losee, Cutress, and Brown, 1973
Testis	19 of 72	ES	<5-10 µg/g ash	<5 µg/g ash (median)	Adults	Tipton and Cook, 1963
Thyroid	11 of 21	ES	<5-82 µg/g ash	5 µg/g ash (median)	Adults	Tipton and Cook, 1963
Total body content	168 samples	NG	9 mg	NG	58 urban and 29 nonurban autopsies	Schroeder, 1970b
Trachea	28 of 60	ES	<5-72 µg/g ash	<5 µg/g ash (median)	Adults	Tipton and Cook, 1963
Urine	2	ES	NG	0.49 ± 0.07 and 0.47 ± 0.06	Healthy 23- and 25-year-old males	Tipton, Stewart, and Dickson, 1969
Uterus	5 of 32	ES	<5-5 µg/g ash	<5 µg/g ash (median)	Adults	Tipton and Cook, 1963

Table 88. Tungsten

Tissue	Number of cases	Analytical method	Range	Mean level	Comment's	Reference
Blood	39	XRS	0.00-0.18 ppm	NG	Healthy men, mean age 35.3 years, serum	Gofman et al., 1964

Table 89. Uranium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00-0.10 ppm	NG	Healthy men, mean age 35.3 years, serum	Gofman et al., 1964

Table 90. Vanadium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adrenal	1 of 13	ES	<1-<1 µg/g ash	<1 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Aorta	100	NG	<0.02-0.065 micromole/g ash	NG		Perry, 1968
	0 of 104	ES	<1-<1 µg/g ash	<1 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Bladder	3 of 110	ES	<1-<1 µg/g ash	<1 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Blood	6 of 89	Ch	>1 µg/100 ml to <2 µg/100 ml	NG	Whole blood from blood donors and preemployment checks, method unable to detect <1 µg/100 ml	Allaway et al., 1968
	39	XRS	0.00-0.11 ppm	NG	Healthy men, mean age 35.3 years, serum	Gofman et al., 1964
	NG	NG	NG	10 µg/liter		Hertz, 1974
Brain	0 of 129	ES	<1-<1 µg/g ash	<1 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Diaphragm	0 of 91	ES	<1-<1 µg/g ash	<1 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Esophagus	5 of 66	ES	<1-<1 µg/g ash	<1 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Feces	2	ES	NG	0.12 ± 0.03 mg/day and 0.15 ± 0.02 mg/day	Healthy 23- and 25-year-old men, University of Cincinnati	Tipton, Stewart, and Dickson, 1969
Hair	267	ES	0.010-2.90 µg/g	0.250 µg/g	Children from Riverhead, Queens, and Bronx	Creason et al., 1975
	193	ES	0.009-2.20 µg/g	0.182 µg/g	Adults from Riverhead, Queens, and Bronx	Creason et al., 1975
	126	ES	NG	0.20 µg/g	Children from Riverhead	Creason et al., 1975
	90			0.24 µg/g	Children from Queens	
	71			0.40 µg/g	Children from Bronx	
	85			0.12 µg/g	Adults from Riverhead	
	77			0.20 µg/g	Adults from Queens	
	49			0.35 µg/g	Adults from Bronx	
Heart	0 of 140	ES	<1-<1 µg/g ash	<1 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Intestine						
Duodenum	5 of 67	ES	<1-<1 µg/g ash	<1 µg/g ash (median)		Tipton and Cook, 1963
Jejunum	4 of 102	ES	<1-<1 µg/g ash	<1 µg/g ash (median)		Tipton and Cook, 1963

Table 90. Vanadium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Ileum	31 of 84	ES	<1-3 µg/g ash	<1 µg/g ash (median)		Tipton and Cook, 1963
Cecum	14 of 31	ES	<1-4 µg/g ash	<1 µg/g ash (median)		Tipton and Cook, 1963
Sigmoid colon	17 of 108	ES	<1-3 µg/g ash	<1 µg/g ash (median)		Tipton and Cook, 1963
Rectum	11 of 42	ES	<1-2 µg/g ash	<1 µg/g ash (median)		Tipton and Cook, 1963
Kidney	0 of 141	ES	<1-<1 µg/g ash	<1 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Larynx	0 of 50	ES	<1-<1 µg/g ash	<1 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Liver	163	C	<1-4.8 ppm ash	<1 ppm ash		Schroeder, Balassa, and Tipton, 1963*b*
	5 of 148	ES	<1-<1 µg/g ash	<1 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Lung	1 of 8	ES	NG	0.22 ppm wet wt	Sudden accident victims, male	Koch et al., 1956
	100	ES	<0.02-0.27 micromole/g ash	NG		Perry, 1968
	150	ES	<0.02-0.26 micromole/g ash	NG		Perry et al., 1962
	168	NG	NG	1.3 µg/year, retained	Samples from 58 cities and 29 nonurban areas, amount retained in lung	Schroeder, 1970*b*
	168	NG	<10-680 µg	NG	Samples from 58 cities and 29 nonurban areas, total lung	Schroeder, 1970*b*
	173	C	0.01 ± 0.0004 to 0.13 ± 0.05 ppm	NG		Schroeder, Balassa, and Tipton, 1963*b*
	73 of 141	ES	<1-13 µg/g ash	<1 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Muscle	0 of 136	ES	<1-<1 µg/g ash	<1 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Omentum	11 of 75	ES	<1-3 µg/g ash	<1 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Ovary	0 of 16	ES	<1-<1 µg/g ash	<1 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Pancreas	2 of 139	ES	<1-<1 µg/g ash	<1 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Placenta	58	NG	NG	0.010 ± 0.010 µg/g wet wt	Southern and southeastern city hospitals	Karp and Robertson, 1977
Prostate	1 of 50	ES	<1-<1 µg/g ash	<1 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963

Table 90. Vanadium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Spleen	1 of 143	ES	<1-<1 μg/g ash	<1 μg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Skin	3 of 21	ES	<1-<1 μg/g ash	<1 μg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Stomach	3 of 130	ES	<1-<1 μg/g ash	<1 μg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Teeth	56	MS	0.01-0.14 μg/g dry wt	0.033 μg/g dry wt	Subjects less than 20 years old	Losee, Cutress, and Brown, 1973
Testis	0 of 72	ES	<1-<1 μg/g ash	<1 μg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Total body content	168	NG		22 mg	Samples from 58 cities and 29 nonurban areas	Schroeder, 1970*b*
Thyroid	1 of 21	ES	<1-<1 μg/g ash	<1 μg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Trachea	0 of 60	ES	<1-<1 μg/g ash	<1 μg/g ash (median)	U.S. adults	Tipton and Cook, 1963
Urine	NG	NG	NG	≤10 μg/liter		Mertz, 1974
	15	ES	NG	Approximately 2 ppb	Normal subjects	Perry, 1968
	15			Approximately 0.95 ppb	Hypertensive	
	8			Approximately 2 ppb	Hypertensive, treated	
	7			Approximately 1.5 ppb	Hypertensive, untreated	
	24	ES	<1.0-22 μg/liter	<6.12 μg/liter	Normal Americans, St. Louis	Perry and Perry, 1959
	10		NG	<3.98 μg/liter	Normal females, St. Louis	
	14		NG	<7.66 μg/liter	Normal males, St. Louis	
	10		NG	<6.85 μg/liter	Negroes, normal, St. Louis	
	14		NG	<5.75 μg/liter	Caucasians, normal, St. Louis	
	8		NG	10.2 μg/liter	Hypercholesterolemic patients ages 21-63 years, three females, five males, before Na_2Ca EDTA administration	
	8		NG	18.0 μg/liter	Hypercholesterolemic patients during Na_2Ca EDTA administration	
	4		NG	4.96 μg/liter	Hypercholesterolemic patients day one after Na_2Ca EDTA administration	
	3		NG	2.60 μg/liter	Hypercholesterolemic patients day two after Na_2Ca EDTA administration	
	2	ES	NG	0.018 ± 0.002 mg/day and 0.23 ± 0.002 mg/day	Healthy 23- and 25-year-old men, University of Cincinnati	Tipton, Stewart, and Dickson, 1969

Table 90. Vanadium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Uterus	1 of 32	ES	<1-<1 µg/g ash	<1 µg/g ash (median)	U.S. adults	Tipton and Cook, 1963

Table 91. Volatile organic compounds

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood, adult and newborn	NG	GC/MS	The following compounds were identified: Acetaldehyde[1,3] Acetone[1,2] Benzaldehyde[1] Benzene[1,2,3] BHT[2] 2-Butanone[1] Carbon tetrachloride[1,2,3] Chloroform[1,2,3] Cyclohexane[1] Cyclohexanone[1] Dichlorobenzene[1,2,3] Dichloromethane[1,2] 1,1-Dichloro-1-nitroethane[1] Dimethyl disulfide[1] Dimethylethylbenzene[1,2] Dipropyl ketone[1] Ethylbenzene[1] γ-Heptalactone[1] Isobutanol[1] Methylcyclopentane[1] Methyl ethyl ketone[1] Methylfuran[1] Methyl isobutyl ketone[1] Methyl mercaptan[1] Methyl propyl ketone[1,2] Pentan-2-one[1] 2-Propanol[1] Pyridine[1] Styrene[1,2] Tetrachloroethylene[1,3] Toluene[1,3] Trimethylbenzene[1,2] 2,4,4-Trimethyl-2-pentane[1] Xylene[1,3]		Superscripts: 1 — adults, 2 — newborn, 3 — identified in municipal water supplies in New Orleans area	Laseter and Dowty, 1977
Blood, maternal and cord	11 pairs	GC/MS	Chromatographic profiles compared. The following compounds were identified: Acetone Benzaldehyde Benzene Carbon tetrachloride Chloroform Cyclohexane Dichlorobenzene 1,1-Dichloro-1-nitroethane		Some selective transfer of compounds to the fetus, for instance, benzene, carbon tetrachloride, and chloroform are present in cord blood in quantities greater than or equal to those in maternal blood, possibility of elution of plasticizers from intravenous apparatus.	Dowty, Laseter, and Storer, 1976 (see Laseter and Dowty, 1977 for distribution between adults and newborns)

Table 91. Volatile organic compounds (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
			Dimethyl disulfide Dimethylethylbenzene Ethylbenzene γ-Heptalactone Isobutanol Methylcyclopentane Methyl ethyl ketone Methyl isobutyl ketone Pentan-2-one Styrene Toluene Trimethylbenzene Xylene		Some of the compounds are in the municipal water supplies in the New Orleans area.	

Table 92. Ytterbium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00-0.31 ppm	NG	Healthy males, age 35.3 years, serum	Gofman et al., 1964

Table 93. Yttrium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Blood	39	XRS	0.00–0.05 ppm	NG	Healthy males, age 35.3 years	Gofman et al., 1964
Teeth	56	MS	0.01–0.17 µg/g dry wt	0.007 µg/g dry wt	Wide geographic area	Losee, Cutress, and Brown, 1973

Table 94. Zinc

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	28	AAS	NG	1850 ± 150 µg/g ash		Schroeder et al., 1967
Adrenal	3	C	8.1-30.2 µg/g dry wt	19.2 and 99.5 g/g dry wt	Range — normal subjects (2), mean — normal and lymphomatous diseased subjects (1) respectively	Koch, Smith, and McNelly, 1957
	15	AAS	NG	1600 ± 70 µg/g ash		Schroeder et al., 1967
	15	ES	1300-2000 µg/g ash	1600 µg/g ash (median)	Adults	Tipton and Cook, 1963
Amniotic fluid	15	AAS	10-65 µg/100 ml	32 µg/100 ml		Henkin, 1971
Aorta	46	AAS	27.9-240.0 µg/g dry wt	49.9-103.0 µg/g dry wt	Autopsies, Chicago area	Marks et al., 1972
	150	ES	17-43 micromoles/g ash	NG	St. Louis adults	Perry et al., 1962
	100	ES	15-54 micromoles/g ash	NG	Adults	Perry, 1968
	104	ES	1100-2700 µg/g ash	1800 µg/g ash (median)	Adults	Tipton and Cook, 1963
Bladder	112	AAS	NG	3200 ± 130 µg/g ash		Schroeder et al., 1967
	112	ES	1800-4900 µg/g ash	3000 µg/g ash (median)	Adults	Tipton and Cook, 1963
Blood						
	704	NAA	NG	36.5 ± 7.9 µg/g dry wt	Nashville, Tennessee hospitals: maternal blood	Baglan et al., 1974
	667	NAA	NG	14.9 ± 8.4 µg/g dry wt	fetal blood	
	282	AAS	150-1730 µg/100 ml	520 µg/100 ml	Newark, New Jersey, children, 1-8 years old	Bogden, Singh, and Joselow, 1974
	520	AAS			Serum:	Bierenbaum et al., 1975
			NG	1.49 ± 0.05 mg/liter	hardwater area, Kansas City, Kansas	
			NG	4.28 ± 0.82 mg/liter	softwater area, Kansas City, Missouri	
	48	ES	NG	0.466 ± 0.013 mg/100 ml	Los Angeles area, normal individuals	Butt et al., 1964
	226	ES			Serum:	Butt et al., 1964
			NG	0.149 ± 0.007 mg/100 ml	blood donors (122)	
			NG	0.152 ± 0.018 mg/100 ml	patients and diseased individuals (96)	
			NG	0.130 ± 0.006 mg/100 ml	normal people (48)	
	502	NG			Maternal blood:	Fahim, Fahim, and Hall, 1976
			NG	69-86 µg/100 ml	control (249)	
			NG	79-86 µg/100 ml	lead mining area (253)	

Table 94. Zinc (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	502	NG			Fetal blood:	Fahim, Fahim, and Hall, 1976
			NG	34-38 µg/100 ml	control (249)	
			NG	32-41 µg/100 ml	lead mining area (253)	
	39	XRS	0.93-1.03 ppm	0.98 ppm	Males, serum	Gofman et al., 1964
	117	AAS			Plasma:	Halsted and Smith, 1970
			72-115 µg/100 ml	96 ± 12 µg/100 ml	adults (151)	
			63-118 µg/100 ml	89 ± 13 µg/100 ml	children (26)	
	20	ES			Plasma:	Hambidge and Droegemueller, 1974
			NG	85.7 ± 2.2 µg/100 ml	males	
			NG	87.9 ± 2.6 µg/100 ml	females	
	40	AAS	NG	54 ± 32 µg/100 ml	Lumber yard workers near fertilizer plant, plasma	Hammer, Finklea, Creason, Sandifer, Kell, Priester, and Stara, 1971
	164	AAS	63-147 µg/100 ml	92 µg/100 ml	Male and female adults, serum	Henkin, 1971
	15	AAS	27-65 µg/100 ml	48 ± 3 and 90 ± 3 µg/100 ml	Range - pregnant women Mean - pregnant women and nonpregnant women, respectively, number of nonpregnant women not given, serum	Henkin, 1971
	15	AAS	70-102 µg/100 ml	83 µg/100 ml	Umbilical cord, serum	Henkin, 1971
	275	AAS, F			Serum:	Henkin et al., 1975
			NG	96 ± 2 ppm	normal individuals (150)	
			NG	77 ± 2 ppm	decreased taste activity individuals (125)	
	59	AAS			Plasma:	Hohnadel et al., 1973
			740-1300 µg/liter	950 µg/liter	men (33)	
			760-980 µg/liter	860 µg/liter	women (15)	
			820-1090 µg/liter	920 µg/liter	women on pill (11)	
	123	C			Plasma:	Koch, Smith, and McNelly, 1957
			34-177 µg/100 ml	120 µg/100 ml	normal individuals (58)	
			80-543 µg/100 ml	140-216 µg/100 ml	lymphomatous diseased individuals (65)	
	243	AAS	60-1987 µg/100 ml	530 µg/100 ml	Males, 19 cities	Kubota, Lazar, and Losee, 1968
	NG	NG	NG	7 µg/ml	Normal level	Rentoul and Smith, 1973
	4	NG	NG	74-116 µg/100 ml	Ages 16.5-19, pregnancy, three sample times	Schraer and Calloway, 1974
	14	Ch, ES	49-85 µg/100 ml	65.6 µg/100 ml	Adult males	Vallee et al., 1957

Table 94. Zinc (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Bone	13	ES	155-372 ppm ash	181 ppm ash	Rib	Alexander and Nusbaum, 1962
	121	AAS	80.5-200.0 µg/g dry wt 117-768 µg/g dry wt	147.1 µg/g dry wt 465.8 µg/g dry wt	Normal bone (40) Osteogenic sarcomas (81)	Janes, McCall, and Elveback, 1972
	6	C	18-34 and 26.4-274.7 µg/g dry wt	26 µg/g dry wt	Range — normal (2) and lymphomatous diseased (4) subjects, respectively, mean — normal subjects	Koch, Smith, and McNelly, 1957
	91	AAS	NG	210 ± 5 µg/g ash		Schroeder et al., 1967
	1	AAS	123-367 µg/g ash	NG	40 samples from one skeleton	Strehlow and Kneip, 1969
Brain	36	AAS	3.75-12.08 µg/g wet wt	5.60 µg/g wet wt	Fetal brain	Chaube, Nishimura, and Swinyard, 1973
	4	C	53.3-189.8 µg/g dry wt	154.4 and 66.9 µg/g dry wt	Range — normal subjects, mean — normal (3) and lymphomatous diseased subjects (1) respectively	Koch, Smith, and McNelly, 1971
	84	ES	NG	4.93 ± 0.21 mg/100 g dry wt	Above 1 year old	Nusbaum et al., 1958
	150	ES	8.0-17.0 micromoles/g ash	NG	St. Louis adults	Perry et al., 1962
	100	ES	8.7-27.0 micromoles/g ash	NG	Adults	Perry, 1968
	NG	NG	NG	39.1 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	129	ES	520-1100 µg/g ash	760 µg/g ash (median)	Adults	Tipton and Cook, 1963
Diaphragm	91	AAS	NG	5000 ± 170 µg/g ash		Schroeder et al., 1967
	91	ES	3300-7200 µg/g ash	4600 µg/g ash (median)	Adults	Tipton and Cook, 1963
Esophagus	67	AAS	NG	3000 ± 170 µg/g ash		Schroeder et al., 1967
	67	ES	1900-4500 µg/g ash	2600 µg/g ash (median)	Adults	Tipton and Cook, 1963
Feces	4	NG	1.54-1.92 mg/g dry wt	1.65 mg/g dry wt	Ages 16.5-19, pregnancy	Schraer and Calloway, 1974
	2	AAS	NG	14.0 ± 1.7 and 16.0 ± 1.4 mg/day	Healthy 23- and 25-year-old males, Cincinnati, Ohio	Tipton, Stewart, and Dickson, 1969
Hair	19	NG	52-119 and 120 µg/g	NG	Wrestlers and nonwrestlers respectively	Anonymous, 1972

Table 94. Zinc (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	33	NAA	51-602 ppm	117 ppm	Adults and children, Oak Ridge, Tennessee	Bate and Dyer, 1965
	144	AAS	NG	136 µg/g 151 µg/g 225 µg/g	Maternal scalp (50) Maternal pubic (51) Neonatal scalp hair (43)	Baumslag et al., 1974
	391	AAS	10.50-450.0 µg/g 20.10-313.0 µg/g	90.50 µg/g 108.54 µg/g	New York suburbs: children (224) adults (167)	Creason et al., 1975
	50	AAS	75-454 ppm 65-308 ppm	156 ppm 173 ppm	Males (25) Females (25)	Eads and Lambdin, 1973
	18	ES	0.0064 and 0.0562% dry wt	NG	White males	Goldblum, Derby, and Lerner, 1953
	168	AAS	40-260 ppm	145.2 ± 30.8 to 156.6 ± 26.0 ppm	Fourth-grade boys, five cities	Hammer, Finklea, Hendricks, Shy, and Horton, 1971
	12	AAS	6.4-87.0 µg/g	18.6 µg/g	Males and females	Hinners et al., 1974
	43	NAA	NG	523.5 µg/g 526.0 µg/g 517.0 µg/g	Control subjects (13) Dialysis subjects (18) Uremic subjects (12)	Mahler et al., 1970
	10	NAA	NG	161.5 ± 14.1 ppm	Homogenized hair	Obrusnik et al., 1972
	211	AAS	NG	90-180 ppm 110-190 ppm	Various age groups: males females	Petering, Yeager, and Witherup, 1971
	NG	NG	NG	173 µg/g dry wt	Normal hair level	Rentoul and Smith, 1973
	180	AAS	NG	167 ± 5 µg/g 172 ± 9.3 µg/g	Males Females	Schroeder and Nason, 1969
	1	AAS	NG	189.4 ± 1.0 µg/g		Sorenson et al., 1973
	6	ES	30-150 ppm	119 ± 4.6 ppm	Seasonal variations, hair analysis reliable	Strain et al., 1966
	2	AAS, MS	NG	246.0 and 181.0 µg/g ash	Methodology	Yurachek, Clemena, and Harrison, 1969
Heart	163	ES	NG	11.85 ± 0.39 mg/100 g dry wt	Above 1 year old	Nusbaum et al., 1958
	150	ES	31-59 micromoles/g ash	NG	St. Louis adults	Perry et al., 1962
	100	ES	26-49 micromoles/g ash	NG	Adults	Perry, 1968
	NG	NG	NG	87.9 µg/g dry wt	Normal level	Rentoul and Smith, 1973

Table 94. Zinc (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	140	ES	2000-3700 µg/g ash	2700 µg/g ash (median)	Adults	Tipton and Cook, 1963
Intestine	15	C	32.2-90.2 µg/g dry wt 42.0-176.3 µg/g dry wt	60.6 µg/g dry wt	Range — normal (10) and lymphomatous diseased (5) subjects respectively, mean — normal subjects, small intestine	Koch, Smith, and McNelly, 1957
Duodenum	68	AAS	NG	2500 ± 74 µg/g ash		Schroeder et al., 1967
Jejunum	103	AAS	NG	2300 ± 67 µg/g ash		Schroeder et al., 1967
Ileum	84	AAS	NG	3200 ± 230 µg/g ash		Schroeder et al., 1967
Cecum	31	AAS	NG	3300 ± 180 µg/g ash		Schroeder et al., 1967
Omentum	73	AAS	NG	1700 ± 88 µg/g ash		Schroeder et al., 1967
Sigmoid colon	108	AAS	NG	2700 ± 79 µg/g ash		Schroeder et al., 1967
Rectum	42	AAS	NG	3500 ± 180 µg/g ash		Schroeder et al., 1967
Duodenum	68	ES	1700-3400 µg/g ash	2400 µg/g ash (median)		Tipton and Cook, 1963
Jejunum	103	ES	1600-3100 µg/g ash	2200 µg/g ash (median)		Tipton and Cook, 1963
Ileum	84	ES	1700-4900 µg/g ash	2800 µg/g ash (median)		Tipton and Cook, 1963
Cecum	31	ES	1900-4400 µg/g ash	3500 µg/g ash (median)		Tipton and Cook, 1963
Sigmoid colon	108	ES	1800-4000 µg/g ash	2600 µg/g ash (median)		Tipton and Cook, 1963
Rectum	42	ES	2400-4800 µg/g ash	3300 µg/g ash (median)		Tipton and Cook, 1963
Kidney	36	AAS	11.34-20.1 µg/g wet wt	15.77 µg/g wet wt	Fetal kidney	Chaube, Nishimura, and Swinyard, 1973
	120	AAS	726-7768 ppm ash	1832-3762 ppm ash	Autopsies, 14 under 6 years old, 106 adults, renal cortex	Hammer et al., 1973
	24	AAS				
			270-5700 µg/g ash 1300-8100 µg/g ash	3500 µg/g ash 4600 µg/g ash	Autopsies: control (12) emphysematics (12)	Hirst et al., 1973
	14	C	83.9-550 µg/g dry wt 167.8-1038.4 µg/g dry wt	375 µg/g dry wt	Range — normal (7) and lymphomatous diseased (7) subjects, respectively, mean — normal subjects	Koch, Smith, and McNelly, 1957
	38	NAA				
			64-126 µg/g dry wt 119-448 µg/g dry wt	91 µg/g dry wt 218 µg/g dry wt	Autopsies: infants (6) adults (32)	Livingstone, 1971

Table 94. Zinc (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	80	AAS	3267-9560 µg/g ash	5168 µg/g ash	Control (traumatic or infectious diseases)	Morgan, 1969
			2210-5858 µg/g ash	4839 µg/g ash	Chronic hypertensives (12)	
			3124-10,110 µg/g ash	5204 µg/g ash	Cardiac or cerebrovascular diseases (18)	
			3689-14,598 µg/g ash	7431 µg/g ash	Malignant diseases (25)	
	104	AAS				
			NG	5307 ± 1797 µg/g ash	103 males, 1 female: control (36)	Morgan, Burch, and Watkins, 1971
				5055 ± 6791 µg/g ash	emphysema and carcinoma (68)	
	35	AAS	61-423 ppm dry wt	181 ppm dry wt	Cortex	Netsky et al., 1969
			60-241 ppm dry wt	125 ppm dry wt	Medulla	
	244	ES	NG	19.04 ± 0.64 mg/100 g dry wt	Above 1 year old	Nusbaum et al., 1958
	150	ES	49-120 micromoles/g ash	NG	St. Louis adults	Perry et al., 1962
	62	ES	1110-8200 µg/g ash	3810-3850 µg/g ash	St. Louis adults and children	Perry et al., 1961
	24	AAS	NG	4620 ± 1960 µg/g ash	Emphysematic (12)	Perry et al., 1972
				3450 ± 1630 µg/g ash	Normal (12)	
	100	ES	35-175 micromoles/g ash	NG	Adults	Perry, 1968
	NG	NG	NG	188 µg/g dry wt	Normal level	Rentoul and Smith, 1973
	40	AAS	NG	287 ± 126 µg/g dry wt	Adults, no metallothionein	Syversen, 1975
	NG	ES	0.0-100+ mg/100 g dry wt	NG		Tietz, Hirsch, and Neyman, 1957
	145	ES	3200-7400 µg/g ash	4500 µg/g ash (median)	Adults	Tipton and Cook, 1963
Larynx	48	AAS	NG	1300 ± 87 µg/g ash		Schroeder et al., 1967
	48	ES	680-2300 µg/g ash	1200 µg/g ash (median)	Adults	Tipton and Cook, 1963
Liver	36	AAS	104.9-231.7 µg/g dry wt	167.7 µg/g wet wt	Fetal liver	Chaube, Nishimura, and Swinyard, 1973
	120	AAS	158-60,260 ppm ash	3297-6354 ppm ash	Autopsies, 14 under 6 years, 106 adults, highest level in 0-9 year age group	Hammer et al., 1973
	24	AAS				
			2500-10,000 µg/g ash	5700 µg/g ash	Autopsies: control (12)	Hirst et al., 1973
			1900-8300 µg/g ash	5000 µg/g ash	emphysematics (12)	
	14	C	223.4-517.0 µg/g dry wt	379 µg/g dry wt	Range - normal (8) and lymphomatous diseased (6) subjects, respectively, mean - normal subjects	Koch, Smith, and McNelly, 1957
			395.8 µg/g dry wt			

Table 94. Zinc (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	80	AAS			79 men, 1 woman:	Morgan, 1969
			3282-16,842 µg/g ash	6463 µg/g ash	control (traumatic or infectious diseases [25])	
			4702-11,238 µg/g ash	7028 µg/g ash	chronic hypertensives (12)	
			2732-17,950 µg/g ash	7404 µg/g ash	cardiac or cerebrovascular diseases (18)	
			3740-21,098 µg/g ash	9678 µg/g ash	malignant diseases (18)	
	104	AAS				
			NG	6062 ± 2311 µg/g ash	103 males, 1 female: control (36)	Morgan, Burch, and Watkins, 1971
				6469-7322 µg/g ash	emphysema and carcinoma (68)	
	35	AAS	51-504 ppm dry wt	207 ppm dry wt	Autopsies	Netsky et al., 1969
	241	ES	NG	21.92 ± 0.70 mg/100 g dry wt	Above 1 year old	Nusbaum et al., 1958
	13	NG	26-48 ppm wet wt	37.2 ppm wet wt	Control (no cancer)	Olson et al., 1954
			53-101 ppm wet wt	80 ppm wet wt	Cancer patient, uninvolved liver	
			14-26 ppm wet wt	18 ppm wet wt	Cancer patient, cancerous liver	
	150	ES	34-92 micromoles/g ash	NG	St. Louis adults	Perry et al., 1962
	62	ES	1400-21,000 µg/g ash	3875-9800 µg/g ash	St. Louis adults and children	Perry et al., 1961
	24	AAS	NG	5040 ± 1670 µg/g ash	Emphysematic (12)	Perry et al., 1972
				5780 ± 2800 µg/g ash	Normal (12)	
	100	ES	44-230 micromoles/g ash	NG	Adults	Perry, 1968
	10	ES	NG	4920 ± 1810 µg/g ash	Five blacks and five whites, St. Louis	Perry et al., 1973
	NG	NG	NG	169 µg/g dry wt	Normal liver level	Rentoul and Smith, 1973
	14	AAS			Adults, no metallothionein detected:	Syversen, 1975
			NG	280 ± 58 µg/g dry wt	cortex	
				221 ± 69 µg/g dry wt	medulla	
	NG	ES	0.0-65+ mg/100 g dry wt	NG		Tietz, Hirsch, and Neyman, 1957
	150	ES	2200-5900 µg/g ash	3500 µg/g ash (median)	Adults	Tipton and Cook, 1963
	14	Ch, ES	NG	74 ppm wet wt	Adult males	Vallee et al., 1957
Lung	24	AAS			Autopsies:	Hirst et al., 1973
			100-1400 µg/g ash	950 µg/g ash	control (12)	
			96-2100 µg/g ash	990 µg/g ash	emphysematics (12)	

Table 94. Zinc (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	13	C	117.2-145.1 µg/g dry wt 78.2-719.8 µg/g dry wt	130.8 µg/g dry wt	Range — normal (5) and lymphomatous diseased (8) subjects, respectively, mean — normal subjects	Koch, Smith, and McNelly, 1957
	26	AAS	24.0-140.0 µg/g dry wt	51.2-102.2 µg/g dry wt	Autopsies, Chicago area	Marks et al., 1972
	35	AAS	53-225 ppm dry wt	85 ppm dry wt	Autopsies	Netsky et al., 1969
	86	ES	NG	8.63 ± 0.39 mg/100 g	Above 1 year old	Nusbaum et al., 1958
	150	ES	13-27 micromoles/g ash	NG	St. Louis adults	Perry et al., 1962
	24	AAS	NG	978 ± 410 µg/g ash 830 ± 410 µg/g ash	Emphysematic (12) Normal (12)	Perry et al., 1972
	100	ES	13-36 micromoles/g ash	NG	Adults	Perry, 1968
	168	NG	6.6-31 mg	NG	Autopsies, urban and rural areas	Schroeder, 1970*b*
	NG	ES	0-20+ mg/100 g dry wt	NG		Tietz, Hirsch, and Neyman, 1957
	141	ES	880-1800 µg/g ash	1300 µg/g ash (median)	Adult	Tipton and Cook, 1963
	141	ES	660-3100 µg/g ash	1400 µg/g ash (median)	Autopsies, nine cities	Tipton and Shafer, 1964
Membrane	502	NG	NG	26-30 µg/100 g 26.5-29.0 µg/100 g	Fetal membrane: control area (249) lead mining area (253)	Fahim, Fahim, and Hall, 1976
Milk	50	AAS	NG	1.68 ± 0.78 µg/ml		Picciano and Guthrie, 1976
Muscle	13	C	62.3-297.3 µg/g dry wt 95.7-144.8 µg/g dry wt	213.4 µg/g dry wt	Range — normal (6) and lymphomatous diseased (7) subjects, respectively, mean normal subjects, cardiac	Koch, Smith, and McNelly, 1957
	13	C	278-642 µg/g dry wt 215.2-349.7 µg/g dry wt	413.6 µg/g dry wt	Range — normal (7) and lymphomatous diseased (6) subjects, respectively, mean — normal subjects	Koch, Smith, and McNelly, 1957
	137	AAS	NG	4800 ± 190 µg/g ash	Striated	Schroeder et al., 1967
	137	ES	2900-6800 µg/g ash	4300 µg/g ash (median)	Adult	Tipton and Cook, 1963
Myocardium	26	AAS	102-284 µg/g dry wt	130-152 µg/g dry wt	Autopsies, Chicago area	Marks et al., 1972
Nails	18	ES	0.0116-0.308% dry wt	NG	White males	Goldblum, Derby, and Lerner, 1953

Table 94. Zinc (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	43	NAA	NG	242 µg/g 445 µg/g 448 µg/g	Finger: control subjects (13) dialysis subjects (18) uremic subjects (12)	Mahler et al., 1979
Omentum	73	ES	940-2900 µg/g ash	1600 µg/g ash (median)	Adult	Tipton and Cook, 1963
Ovary	16	AAS	NG	1800 ± 210 µg/g ash		Schroeder et al., 1967
	16	ES	840-2700 µg/g ash	1700 µg/g ash (median)	Adult	Tipton and Cook, 1963
Pancreas	9	C	114-195 µg/g dry wt 92.4-180.6 µg/g dry wt	168 µg/g dry wt	Range - normal (4) and lymphomatous diseased (5) subjects, respectively, mean - normal subjects	Koch, Smith, and McNelly, 1957
	138	ES	1500-3500 µg/g ash	2300 µg/g ash (median)	Adult	Tipton and Cook, 1963
Placenta	811	NAA	NG	70.5 ± 13.5 µg/g dry wt	Nashville, Tennessee, hospitals	Baglan et al., 1974
	554	AAS	NG	28.82 ± 20.77 micromoles/g dry wt	Normal deliveries, Houston	Dawson et al., 1969
	554	AAS	NG	13.80 ± 0.39 to 50.37 ± 3.58 micromoles/g	Range of monthly means	Dawson et al., 1968
	502	NG	NG	26.5-31.0 µg/100 g 26.0-31.5 µg/100 g	Control (249) Lead mining area (253)	Fahim, Fahim, and Hall, 1976
	58	NG	NG	10.232 ± 0.481 µg/g wet wt	Southern and southeastern city hospitals	Karp and Robertson, 1977
Prostate	50	AAS	NG	9200 ± 860 µg/g ash		Schroeder et al., 1967
	50	ES	3200-19,000 µg/g ash	7500 µg/g ash (median)	Adults	Tipton and Cook, 1963
Saliva	81	AAS	NG	51 ± 14 ppb 10 ± 6 ppb	Parotid saliva: normal (34) idopathic hypogeusia (47)	Henkin, Mueller, and Wolf, 1975
	275	AAS F	NG	51 ± 3 ppb 10 ± 1 ppb	Normal (150) Decreased taste activity (125)	Henkin, Mueller, and Wolf, 1975
Skin	18	ES	0.002-0.0678% dry wt	NG	White males	Goldblum, Derby, and Lerner, 1953
	7	C	6.2-112.4 µg/g dry wt	NG	Lymphomatous diseased subjects	Koch, Smith, and McNelly, 1957

Table 94. Zinc (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	21	AAS	NG	1000 ± 230 µg/g ash		Schroeder et al., 1967
	21	ES	550–1000 µg/g ash	780 µg/g ash (median)	Adults	Tipton and Cook, 1963
Spleen	11	C	63.3–138.3 µg/g dry wt 92.1–130.7 µg/g dry wt	113.4 µg/g dry wt	Range – normal (6) and lymphomatous diseased (5) subjects, respectively, mean – normal subjects	Koch, Smith, and McNelly, 1957
	26	AAS	62.2–154 µg/g dry wt	77.9–91.0 µg/g dry wt	Autopsies, Chicago area	Marks et al., 1972
	87	ES	NG	8.57 ± 0.38 mg/100 g dry wt	Above 1 year old	Nusbaum et al., 1958
	150	ES	15–29 micromoles/g ash	NG	St. Louis adults	Perry et al., 1962
	100	ES	15–36 micromoles/g ash	NG	Adults	Perry, 1968
	142	ES	1000–1900 µg/g ash	1300 µg/g ash (median)	Adults	Tipton and Cook, 1963
Stomach	7	C	78.7–185 µg/g dry wt 73.7–144.2 µg/g dry wt	152.7 µg/g dry wt	Range – normal (4) and lymphomatous diseased (3) subjects, respectively, mean – normal subjects	Koch, Smith, and McNelly, 1957
	130	AAS	NG	2600 ± 69 µg/g ash		Schroeder et al., 1967
	130	ES	1700–3400 µg/g ash	2400 µg/g ash (median)	Adults	Tipton and Cook, 1963
Sweat	48	AAS	130–1460 µg/liter 530–2620 µg/liter	500 µg/liter 1250 µg/liter	Men (33) Females (15) Comparison to women on pill showed no difference	Rohnadel et al., 1973
	4	NG	2.47–3.49 mg/day	2.84 mg/day	Ages 16.5–19, pregnancy	Schraer and Calloway, 1974
Teeth	35	AAS	1210–3950 ppm	1620 ± 460 ppm	Left maxillary central incisor, 9–15 years old	Brudevold et al., 1975
	38	XRS	NG	151.0 ± 30.5 µg/g	Californians, dentin	Kuhnlein and Calloway, 1977
	56	MS	42–510 µg/g	203 µg/g	Less than 20-year-old teeth, enamel	Losee, Cutress, and Brown, 1973
Testis	71	AAS	NG	1500 ± 64 µg/g ash		Schroeder et al., 1967
	71	ES	900–2200 µg/g ash	1400 µg/g ash (median)	Adults	Tipton and Cook, 1963
Thyroid	21	AAS	NG	2900 ± 260 µg/g ash		Schroeder et al., 1967

Table 94. Zinc (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
	21	ES	1700–4000 µg/g ash	2700 µg/g ash (median)	Adults	Tipton and Cook, 1963
Trachea	60	AAS	NG	980 ± 62 µg/g ash		Schroeder et al., 1967
	60	ES	450–1800 µg/g ash	890 µg/g ash (median)	Adults	Tipton and Cook, 1963
Umbilical cord	502	NG	NG	27–29 µg/100 g 24–29 µg/100 g	Control area (249) Lead mining area (253)	Fahim, Fahim, and Hall, 1976
Urine	19	NG	166–323 µg/24-hr sample 400–800 µg/24-hr sample	NG	Wrestlers Nonwrestlers	Anonymous, 1972
	40	AAS	NG	630 ± 550 µg/100 ml	Lumberyard workers near fertilizer plant	Hammer, Finklea, Creason, Sandifer, Keil, Priester, and Stara, 1971
	164	AAS	141–779 µg/100 ml	353 µg/100 ml	Male and female adults	Henkin, 1971
	24	ES	82–740 µg/liter	318 µg/liter	Black and white males and females	Perry and Perry, 1959
	38	NG	NG	85 ppb 125 ppb 85 ppb	Normal subjects (15) Hypertensive subjects (15) Treated hypertensive subjects (8)	Perry, 1968
	NG	NG	NG	0.5 µg/ml	Normal level	Rentoul and Smith, 1973
	4	NG	0.49–0.82 mg/day	0.62 mg/day	Ages 16.5–19, pregnancy	Schraer and Calloway, 1974
	2	AAS	NG	1.3 ± 0.1 and 1.2 ± 0.2 mg/day	Healthy 23- and 25-year-old males, Cincinnati, Ohio	Tipton, Stewart, and Dickson, 1969
	32	AAS	NG	2590 ± 290 µg/g ash		Schroeder et al., 1967

Table 95. Zirconium

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Adipose	3	C	2.94-42.27 µg/g ash	18.71 µg/g ash	Autopsies: Dallas, Baltimore, and Miami	Schroeder and Balassa, 1966
Aorta	1	C	NG	9.49 µg/g ash	Autopsies: Dallas, Baltimore, and Miami	Schroeder and Balassa, 1966
Blood	39	XRS	0.00-0.20 ppm	NG	Healthy males, age 35.3 years, serum	Gofman et al., 1964
	4	C	NG	0.40 µg/g 1.25 µg/g	Serum: 18 years old 40 years old	Schroeder and Balassa, 1966
	4	C	NG	6.40 µg/g 6.02 µg/g	Red blood cells: 18 years old 40 years old	Schroeder and Balassa, 1966
Brain	4	C	0.26-6.40 µg/g ash	2.61 µg/g ash	Autopsies: Dallas, Baltimore, and Miami	Schroeder and Balassa, 1966
Diaphragm	1	C	NG	3.49 µg/g ash	Autopsies: Dallas, Baltimore, and Miami	Schroeder and Balassa, 1966
Feces	2	ES	NG	0.12 ± 0.02 and 0.059 ± 0.008 mg/day	Healthy 23- and 25-year-old males, University of Cincinnati	Tipton et al., 1969
Gall bladder	1	C	NG	13.92 µg/g ash	Autopsies: Dallas, Baltimore, and Miami	Schroeder and Balassa, 1966
Heart	4	C	0.74-4.13 µg/g ash	1.81 µg/g ash	Autopsies: Dallas, Baltimore, and Miami	Schroeder and Balassa, 1966
Intestine	2	C	0.36-1.16 µg/g ash	0.76 µg/g ash	Autopsies: Dallas, Baltimore, and Miami, jejunum	Schroeder and Balassa, 1966
Kidney	4	C	0.65-5.39 µg/g ash	2.70 µg/g ash	Autopsies: Dallas, Baltimore, and Miami	Schroeder and Balassa, 1966
Liver	3	C	1.35-9.19 µg/g ash	6.28 µg/g ash	Autopsies: Dallas, Baltimore, and Miami	Schroeder and Balassa, 1966
Lung	168	NG	Max — 7890	NG	58 cities and 29 nonurban areas	Schroeder, 1970*b*
	4	C	1.18-7.49 µg/g ash	3.46 µg/g ash	Autopsies: Dallas, Baltimore, and Miami	Schroeder and Balassa, 1966

Table 95. Zirconium (continued)

Tissue	Number of cases	Analytical method	Range	Mean level	Comments	Reference
Muscle	1	C	NG	2.63 µg/g ash	Autopsies: Dallas, Baltimore, and Miami, psoas muscle	Schroeder and Balassa, 1966
Pancreas	3	C	1.32-3.50 µg/g ash	2.06 µg/g ash	Autopsies: Dallas, Baltimore, and Miami	Schroeder and Balassa, 1966
Spleen	4	C	0.65-3.39 µg/g ash	1.88 µg/g ash	Autopsies: Dallas, Baltimore, and Miami	Schroeder and Balassa, 1966
Stomach	2	C	1.52-1.76 µg/g ash	1.64 µg/g ash	Autopsies: Dallas, Baltimore, and Miami	Schroeder and Balassa, 1966
Teeth	208	MS			Subjects less than 20 years old:	Curzon and Losee, 1977
			NG	0.27 ± 0.10 ppm	high caries	
				0.16 ± 0.09 ppm	low caries	
	56	MS	0.02-2.60 µg/g dry wt	0.53 ± 0.08 µg/g dry wt	Subjects less than 20 years old, wide geographic area	Losee et al., 1973
Testis	4	C	0.93-2.04 µg/g ash	1.37 µg/g ash	Autopsies: Dallas, Baltimore, and Miami	Schroeder and Balassa, 1966
Total body content	168	NG	NG	420 mg	National survey	Schroeder, 1970*b*
Urine	5	C	NG	0.0 at µg/g level	One female, four males, age 18-80 years	Schroeder and Balassa, 1966
	2	ES	NG	0.084 ± 0.014 and 0.18 ± 0.06 mg/day	Healthy 23- and 25-year-old males, University of Cincinnati	Tipton et al., 1969

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